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Hydropower Potential of the United States with Emphasis on Low Head/Low Power Resources

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Hydropower Potential of the United States with Emphasis on Low Head/Low Power Resources

Douglas G. Hall, INEEL
Shane J. Cherry, INEEL
Kelly S. Reeves, NPS
Randy D. Lee, INEEL
Gregory R. Carroll, BNI
Garold L. Sommers, INEEL

IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

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ABSTRACT

Analytical assessments of the hydropower potential in the 18 hydrologic regions of the conterminous United States were performed using state-of-the-art digital elevation models and geographic information system tools. The principal focus of the study was the amount of low head (less than 30 ft)/low power (less than 1 MW) potential in each region. To obtain these estimates, the hydropower potential of all the stream segments in a region, which averaged 2 miles in length, were calculated. These calculations were performed using hydrography and hydraulic heads that were obtained from the U.S. Geological Survey's Elevation Derivatives for National Applications dataset and stream flow predictions from a regression equation developed specifically for the region. Stream segments excluded from development and developed hydropower were accounted for to produce an estimate of total available hydropower potential. The total available hydropower potential was subdivided into high power (1 MW or more), high head (30 ft or more)/low power, and low head/low power total potentials. The low head/low power potential was further divided to obtain the fractions of this potential corresponding to the operating envelopes of three classes of hydropower technologies: conventional turbines, unconventional systems, and microhydro (less than 100 kW). Summing information for all the regions provided total hydropower potential in various power classes for the entire conterminous United States. Distribution maps show the location and concentrations of the various classes of hydropower potential. No aspect of the feasibility of developing these potential resources was evaluated. Results for each of the 18 hydrologic regions are presented in Appendix A, and similar presentations for each of the 48 states are made in Appendix B.

SUMMARY

The U.S. Department of Energy (DOE) has an ongoing interest in assessing the hydropower potential of the United States. Previous assessments have focused on potential projects having a capacity of 1 MW and above. These assessments were also based on previously identified sites with a recognized, although varying, level of development potential. In FY 2000, DOE initiated planning for an assessment of hydropower potential for low head (less than 30 ft) and low power (less than 1 MW) resources.

The Idaho National Engineering and Environmental Laboratory in conjunction with the U.S. Geological Survey recently completed assessments of all 18 hydrologic regions in the conterminous United States, which in combination provide assessment results for this entire area of the United States. Parsing of the regional assessment results using geographic information system (GIS) tools produced assessment results for each of the 48 states in the conterminous United States. The assessments provided not only estimates of the amount of low head/low power potential, but also estimates of hydropower potential in several power classes defined by power level and hydraulic head, and estimates of total hydropower potential for most of the country.

The method used in this study uses state-of-the-art digital elevation models and GIS tools to assess the hydropower potential of a mathematical analog every stream segment within each region. Man-made streams such as canals and effluent streams were not included. Summing the estimated hydropower potential of all the stream segments in the region provided an estimate of the total hydropower potential in the region. Stream segments that had power potentials less than 1 MW and hydraulic heads less than 30 ft were segregated and summed to provide an estimate of total low head/low power potential in the region. Having hydropower potential estimates in such small increments allowed the low head/low power potential to be further divided to determine the amounts of potential corresponding to the operating envelopes of three classes of low head/low power hydropower technologies: conventional turbines, unconventional systems, and microhydro.

In order to calculate the hydropower potential of each stream segment, the hydrography in the region was derived using the U.S. Geological Survey's Elevation Derivatives for National Applications (EDNA) dataset. In addition to the hydrography, the dataset provided the elevations of the upstream and downstream ends of each stream segment, which were used to calculate hydraulic head. The dataset also allowed the calculation of the drainage area providing runoff to each stream segment. Overlaying the EDNA data with climatic data from the Parameter-elevation Regressions on Independent Slopes Model dataset provided the variables needed to calculate stream flow rate for each stream segment using regression equations developed specifically for each region in the study area. Combining stream flow rate with hydraulic head provided the hydropower potential of the stream segment.

Because the hydrography used was "synthetic," stream segments were compared to streams in the U.S. Geological Survey's National Hydrography Dataset. Unconfirmed stream segments were eliminated from the datasets that

were used to estimate total hydropower potentials. A GIS layer containing streams and areas that are excluded from development by federal statutes and policies was used to segregate excluded and nonexcluded stream segments. The amount of hydropower potential that has already been developed in the region was derived from average annual electricity generation data provided by the Federal Energy Regulatory Commission's Hydroelectric Power Resources Assessment (HPRA) Database. Developed hydropower potential was subtracted from the total, nonexcluded, hydropower potential in each power class to produce estimates of available hydropower potentials. No feasibility assessments were made; therefore, the results are gross numbers that do not include the elimination of sites that probably would not be developed at this time. Also, "available" hydropower potential only refers to amounts of potential that have not been developed and are not excluded from development by federal statute or policy. No assessment of availability for hydropower development was performed.

The assessment estimated that the total hydropower potential of the conterminous United States is approximately 200,000 MW. Of this amount, about 46,000 MW is excluded from development. With about 35,000 MW already developed (corresponding to approximately 75,000 MW of the total capacity), the total available hydropower potential is estimated to be about 120,000 MW or 60% of the total hydropower potential. Low head/low power potential makes up about 19,000 MW of the total available potential. Division of the available low head/low power potential among low head/low power technology classes showed that 35% fell within the operating envelope of conventional turbines, 15% fell within the operating envelope of unconventional systems, and 50% fell within the operating envelope of microhydro technologies. In addition to the low head/low power potential, it is estimated that there is a total of 20,000 MW of high head (30 ft or greater)/low power potential available in the 48 states. A map of the locations of low head/low power sites by technology class shows that conventional turbine sites and unconventional system sites are numerous except in the central part of the country, arid areas of the West and where there are high concentrations of high power or high head/low power potential. Microhydro sites are abundant and exist everywhere in the country except in the plains from North Dakota to the Texas panhandle. A second map shows that high head/low power sites are abundant and are generally located in the mountainous areas of the country.

The regional and state potentials are compared to each other and to the total results for the 18 regions and 48 states. These comparisons show that a majority of the regions and states are underdeveloped with regard to hydroelectric power compared to the averages for the country both from the perspective of percentage of potential developed to date and the percentage of potential that is available for development. Most of the available hydropower potential is concentrated in 4 Western states and 12 states east of the Mississippi River. The states having the highest concentrations of low head/low power potential are all in the eastern United States with the vast majority being east of the Mississippi River; but in general, low power (<1 MW) sites exist in large numbers throughout the country.

The study showed that the combined amounts of available high head/low power and low head/low power hydropower potential in the study area constitutes one-third of the total available potential. However, realizing nearly two-thirds of the low head/low power potential would require unconventional systems or microhydro technology requiring significant turbine and system configuration research and development. The fact that this source of distributed power could be realized without the need for water impoundments is a positive attribute. The greatest sources for additional hydropower lie in the combination of high power sites, high head/low power sites, and part of the low head/low power potential sites, constituting 90% of the total, available hydropower potential. This potential could be realized with conventional turbine technology, but perhaps in new configurations not requiring impoundments determined by future research and development.

The assessment results for each of the hydrologic regions are presented in Appendix A. Each subsection is devoted to a specific region and contains a description of the region with a map showing its geographic and hydrographic features. The regional assessment results are presented in a table listing hydropower potential by power class and category. Pie charts illustrate the division of total hydropower potential, available hydropower potential, and low head/low power hydropower potential amongst their constituent parts. A two-part map shows the locations of existing power plants, high head/low power potential, and low head/low power sites. Similar presentations of assessment results for each state are made in Appendix B.

For further information or comments, please contact:

Douglas G. Hall, Project Manager
Low Head/Low Power Hydropower Resource Assessment Project
Idaho National Engineering and Environmental Laboratory
P.O. Box 1625, MS 3850
Idaho Falls, ID 83415-3850
Phone: (208) 526-9525
E-mail: *dgh@inel.gov*

Garold L. Sommers, Program Manager
Hydropower Program
Idaho National Engineering and Environmental Laboratory
P.O. Box 1625, MS 3830
Idaho Falls, ID 83415-3830
Phone: (208) 526-1965
E-mail: *sommergl@inel.gov*

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FIGURES

TABLES

ACRONYMS

BNI	Bechtel National, Incorporated
DOE	U.S. Department of Energy
EDNA	Elevation Derivatives for National Applications An analytically derived, three-dimensional dataset in which hydrologic features have been determined based on elevation data from the NED resulting in three-dimensional representations of "synthetic streams" (stream path coordinates plus corresponding elevations) and an associated catchment boundary for each synthetic reach (based on 1:24K-scale data for the conterminous United States and 1:63,360-scale data for Alaska) (*Note: EDNA synthetic stream reaches do not uniformly coincide with NHD reaches. Conflation of EDNA and NHD features to improve the quality of both datasets is a later phase EDNA development.) (http://mn.water.usgs.gov/uzig/eros.reed.doc)*
FERC	Federal Energy Regulatory Commission
GIS	Geographic Information System A set of digital geographic information, such as map layers and elevation data layers, that can be analyzed using both standardized data queries as well as spatial query techniques.
HPRA	Hydroelectric Power Resources Assessment
HUC	hydrologic unit code
INEEL	Idaho National Engineering and Environmental Laboratory
NED	National Elevation Dataset A three-dimensional representation of topographic features composed of geographic coordinates on a 30-m grid with corresponding elevations that numerically represent the topography based on 1:24K-scale data for the conterminous United States and 1:63,360-scale data for Alaska (available for the entire United States from the U.S. Geological Survey). (http://gisdata.usgs.net/ned/)
NHD	National Hydrography Dataset A comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs, and wells. (http://nhd.usgs.gov)
NPS	Nuclear Placement Services
PRISM	Parameter-elevation Regressions on Independent Slopes Model An expert system that uses point data and a digital elevation model to generate gridded estimates of climate parameters. *(http://www.ocs.orst.edu/prism/overview.html)*
USGS	U.S. Geological Survey

NOMENCLATURE

Annual mean flow rate	The statistical mean of the flow rates occurring at a particular location during the course of 1 year.
Annual mean power	A power rating of a hydroelectric plant based on the generation at this value throughout the course of a year would produce the average annual electricity generation of the plant; average megawatt power rating denoted by a MW.
Capacity	Typically refers to the design power rating of a hydroelectric plant and is on the average of twice the annual mean power of the plant for existing United States hydroelectric plants.
Catchment	That portion on a drainage basin supplying runoff to a particular stream reach.
Drainage area	The total surface area of the topography of a drainage basin.
Drainage basin	The geographic area supplying runoff to a particular point on a stream equal to the area of all the catchments associated with upstream stream reaches supplying flow to the point.
EDNA stream node	Starting point of an EDNA synthetic stream, a confluence, or an intermediate point on an EDNA stream defined as a result of having 5,000 National Elevation Data tiles (30×30 m) supplying runoff to the portion of an EDNA synthetic stream between this point and the EDNA node immediately upstream (Note: Each node has an associated catchment and is a pour point.)
EDNA stream reach	That portion of an EDNA synthetic stream between two EDNA stream nodes.
Hydropower potential	Ideal hydroelectric power based on an annual mean flow rate and an associated hydraulic head. (Note: In the case of the developed hydropower potential of an actual hydroelectric plant, the developed hydropower potential is approximated by the annual mean power of the plant.)
Pour point flow rate	The estimated flow rate of a stream reach equal to the runoff rate from the corresponding drainage basin.
Power category	The power category names used in this report to differentiate between different categories of hydropower potential are: “total,” “developed,” “excluded,” and “available.” “Total” refers to all the hydropower potential in a study area. “Developed” refers to the hydropower potential corresponding to the sum of the annual mean power of all the existing hydroelectric plants in a study area. “Excluded” refers to the hydropower potential existing within zones in a study area where hydropower development is prohibited by federal law or policy. “Available” refers to the balance of hydropower potential after subtracting amounts of developed and excluded potential from the total amount. (Note: “Available” only means that the hydropower potential has not been developed and is not excluded from development by federal law or policy. It does not denote availability based on ownership or control or that the potential can feasibly be developed.)

Power class

The power classes into which hydropower potential has been divided this report include:

- Total power = high power + low power
- High power = high head/high power + low head/high power
- High head/high power
- Low head/high power
- Low power = high head/low power + low head/low power
- High head/low power
- Low head/low power

where high power refers to ≥1 MW, low power refers to <1 MW, high head refers to ≥30 ft, and low head refers to <30 ft.

Additional power classes include those corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro low head/low power technologies. (Note: See Figure 5 for boundaries of these power classes.)

Hydropower Potential of the United States with Emphasis on Low Head/Low Power Resources

1. INTRODUCTION

In June 1989, the U.S. Department of Energy (DOE) initiated the development of a National Energy Strategy to identify the energy resources available to support the expanding demand for energy in the United States. Past efforts to identify and measure the undeveloped hydropower capacity in the United States have resulted in estimates ranging from about 70,000 MW to almost 600,000 MW. The Federal Energy Regulatory Commission's (FERC's) estimate was about 70,000 MW, and the U.S. Army Corps of Engineers' theoretical estimate was 580,000 MW. Public hearings conducted as part of the strategy development process indicated that the undeveloped hydropower resources were not well defined. One of the reasons was that no agency had previously estimated the undeveloped hydropower capacity based on site characteristics, stream flow data, and available hydraulic heads.

As a result, DOE established an interagency Hydropower Resources Assessment Team to ascertain the country's undeveloped hydropower potential. The team consisted of representatives from each power marketing administration (Alaska Power Administration, Bonneville Power Administration, Western Area Power Administration, Southwestern Power Administration, and Southeastern Power Administration), the Bureau of Reclamation, the Army Corps of Engineers, the FERC, the Idaho National Engineering and Environmental Laboratory (INEEL), and the Oak Ridge National Laboratory. The interagency team drafted a preliminary assessment of potential hydropower resources in February 1990. This assessment estimated that 52,900 MW of undeveloped hydropower capacity existed in the United States.

Partial analysis of the hydropower resource database by groups in the hydropower industry indicated that the hydropower data included redundancies and errors that reduced confidence in the published estimates of developable hydropower capacity. DOE has continued assessing hydropower resources to correct these deficiencies, improve estimates of developable hydropower, and determine future policy. Modeling of the undeveloped hydropower resources in the United States identified 5,677 sites that have a total undeveloped capacity of about 70,000 MW (Connor et al. 1998). Consideration of environmental, legal, and institutional constraints resulted in an estimate of about 30,000 MW of viable, undeveloped United States hydropower resources.

The previous resource assessments have focused on potential projects that have a capacity of 1 MW or more. DOE identified a need to assess the United States hydropower resources for projects of less than 1 MW. In FY 2000, DOE initiated planning for an assessment of hydropower potential for low head (less than 30 ft) and low power (less than 1 MW) resources. The INEEL in conjunction with the U.S. Geological Survey completed a pilot low head/low power hydropower resource assessment of the Arkansas-White-Red hydrologic region in July 2002 (Hall et al. 2002a). The principal objective of this pilot study was to develop and demonstrate a method of estimating the hydropower potential of a large geographic area. The method that was developed uses state-of-the-art digital elevation models and geographic information system tools. Using this method, the hydropower potential of a mathematical analog of every stream segment within a chosen study area is assessed. Summing the estimated hydropower potential of all the stream segments in the area provides an estimate of the total hydropower potential of the area. This method was subsequently used to assess the Pacific Northwest hydrologic region as a demonstration of its applicability to a region with large extremes in elevation and hydrology. The results of this study are reported in Hall et al. 2002b. An additional regional assessment was undertaken at the request of DOE, which assessed the combined study area of the North Atlantic and Mid-Atlantic hydrologic regions. The results of this study are reported in Hall et al. 2003.

The ultimate objective of the project that produced the four regional assessments is to produce a fundamental assessment of the hydropower potential of the entire United States with emphasis on low head/low power resources. This has been accomplished for the study area consisting of the conterminous United States (48 states) by assessing the remaining 14 hydrologic regions and collating the regional data into results for the entire study area. These results were subsequently parsed to produce results for each of the 48 states in the study area. Assessments for the states/hydrologic regions of Alaska and Hawaii remain to be completed. The method used to determine hydropower potential did not include evaluating any aspect of the feasibility of developing a discrete hydropower potential resource or collective group of resources other than location inside or outside a zone in which hydropower development is prohibited by federal law or policy. The study also did not include assessment of the hydropower potential of any man-made streams such as canals or effluent streams.

The assessment results reported in this document were analytically derived using validated mathematical analogs of stream segments and predictive equations to calculate their annual mean flow rate. Although the results have significant uncertainties, they provide important information about the hydropower potential of the United States. First, they provide an estimate of the magnitude of the total United States hydropower source for comparison with other energy sources available to meet the United States energy demand. Second, the results indicate the relative amounts of hydropower in various power classes that are defined by power level and the hydraulic head used to produce the power. This provides guidance about the relative amounts of potential that could be captured by conventional and nonconventional hydropower technologies. Third, they indicate the relative amounts of potential available to be captured by three classes of low head/low power hydropower technologies that will guide research and development of these technologies. Fourth, the results estimate the amounts of hydropower potential and percentages of development and exclusion from development to date, and indicate the relative concentrations of potential by hydrologic regions and states to identify geographic areas of opportunity. Finally, they indicate discreet locations of hydropower potential to guide more in-depth site assessments.

The analysis method employed produced hydropower potential estimates in stream segment increments that allowed the total hydropower potential in the study area to be divided into subcategories: high power potential (1 MW or greater), high head/low power potential (less than 1 MW with 30 ft of hydraulic head or greater), and low head/low power (less than 1 MW with generally less than 30 ft of hydraulic head). It also allowed the low head/low power potential to be further divided to determine the amounts of potential corresponding to the operating envelopes of three classes of low head/low power hydropower technologies: conventional turbines, unconventional systems, and microhydro.

The reader is cautioned about an important distinction that is made in the presentation of assessment results in this report. The assessment method used produced estimates of hydropower potential. This parameter is not the same as hydropower capacity, which has been assessed in other assessment efforts. The difference lies in potential being based on estimates of annual mean flow rate combined with local hydraulic head to produce an estimate of annual mean power potential in the present study. In contrast, hydropower capacity is the design power capacity of a real or hypothetical hydroelectric plant. Plant design capacity is determined by anticipated flow rates, which may not be natural stream flows, economic considerations, and other factors. Because the assessment results are hydropower potential values rather than plant capacity values, total hydropower potential values listed in this report will appear low when compared with the results of prior assessments, which are based on owners' selections of design capacity or an economic model that selects a design capacity.

The amount of hydropower potential that has been developed is accounted for in the available power potentials presented in this report and is a derived value based on average annual electricity generation. Plant capacity values are not used to account for developed power. The regional reports referred to above did not account for the distinction between developed power potential and developed capacity and simply used total developed capacity for the amount of potential that had been developed in the region. Because these larger values were used, the available power potential values in these reports are, therefore, less than comparable values listed in this report.

It is recommended that the information in this report supersede that in the prior regional reports. At the same time, it should be considered that the available power potential values listed in this report were derived by subtracting developed potential based on actual, average plant generation from ideal power potential. Ideal potential values do not account for plant efficiency or any aspect of plant operations. It should also be noted that the term "available" power potential only denotes an amount of potential equal to the difference between the total amount of potential and the amounts of developed potential and potential excluded from development by federal statute or policy in a specific area. "Available" does not denote any knowledge on the part of the authors of interest in or intent to develop any hydropower resource.

This report is being issued in draft form to make the assessment results for the conterminous United States available at the earliest possible time. The assessments of the two remaining states/hydrologic regions will be incorporated into the report prior to its being issued in its final form. The current timeframe for publication of the final version of the report is the first quarter of calendar year 2004.

This report is organized by presenting a description of the study area, details of the assessment method that was employed to perform the assessments, and the results of the assessments considering the study area at large. Regional assessment results are presented in Appendix A. These results were combined and segregated along state boundaries to produce assessment results by state, which are presented in Appendix B. The report ends with conclusions based on the results and recommendations for further research and refinement of the technical method.

2. STUDY AREA—EIGHTEEN HYROLOGIC REGIONS OF THE CONTERMINOUS UNITED STATES

The conterminous United States is divided into 18 hydrologic regions as shown in Figure 1, with the remaining three regions being Alaska, Hawaii, and Puerto Rico. The hydrologic regions have been numbered using a hydrologic unit code (HUC) of 1 through 21. For example, the North Atlantic Hydrologic Region has been assigned a hydrologic unit code of 1 and is sometimes referred to as “HUC 1.” Table 1 provides the names of the hydrologic regions by region or HUC number.

The conterminous United States, from east to west, consists of a coastal plain along the Atlantic, the Appalachian Mountains, a vast interior lowland, and the western Cordillera, a wide system of mountains and valleys extending to the Pacific Ocean. The Atlantic Coastal plain is narrow in the mid-Atlantic states, but gradually widens toward the south to form a broad coastal plain in the Carolinas and Georgia. Estuaries and bays form deep indentations in the coastal plain, especially Delaware Bay and Chesapeake Bay in Delaware, Maryland, and Virginia. Inland from the coastal plain, the Piedmont forms a gentle rolling upland that borders the eastern slope of the Appalachians. The Appalachian Mountains form a long southwest-northeast trending chain of mountains that extend from northern Alabama to New England. From New York southward, the Appalachians are composed of a long series of alternating ridges and valleys, created by folding and erosion of ancient rock layers. The mountains continue into New England, but the ridge and valley pattern is absent. Breaks in mountain ridges, known as “water gaps,” allow several major rivers to cross part or all of this mountain chain, for example, the Connecticut River in New England, the Hudson River in New York, the Delaware River in Pennsylvania, the Susquehanna River in New York, Pennsylvania, and Maryland, and the Potomac River in Virginia, West Virginia, and Maryland.

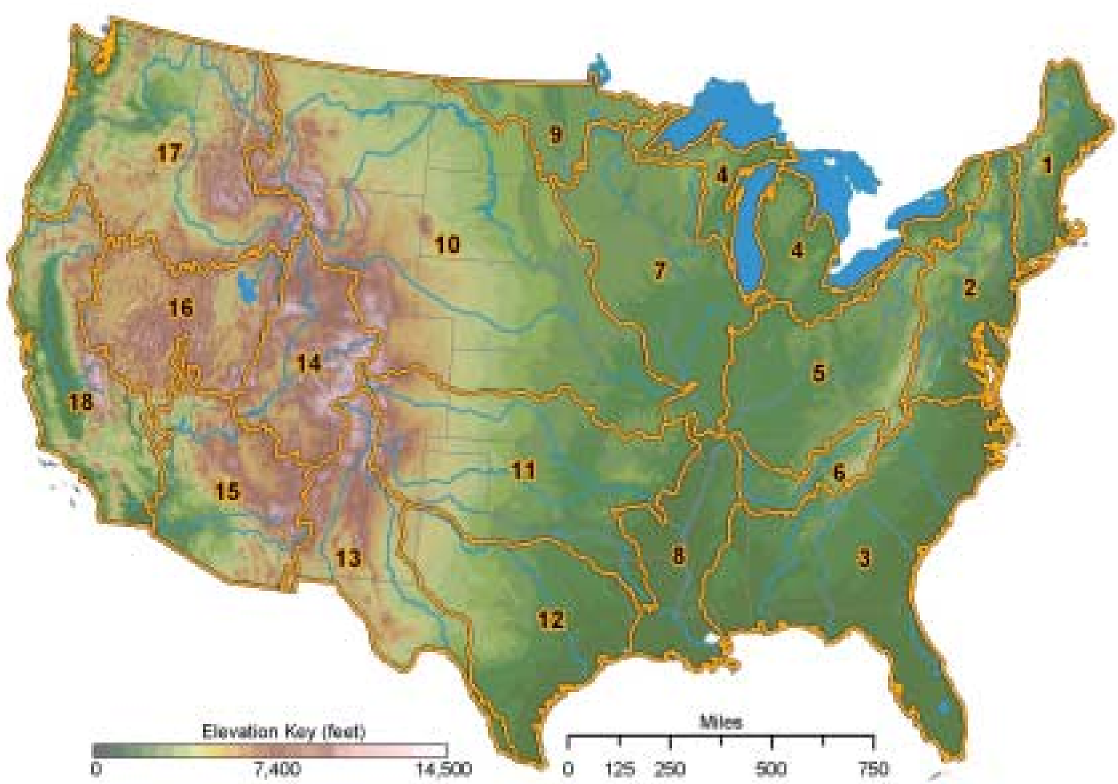

Figure 1. The 18 hydrologic regions (units) of the conterminous United States.

Table 1. Hydrologic regions of the conterminous United States.

Region (HUC) No.	Name
1	North Atlantic
2	Mid-Atlantic
3	South Atlantic-Gulf
4	Great Lakes
5	Ohio
6	Tennessee
7	Upper Mississippi
8	Lower Mississippi
9	Souris Red-Rainy
10	Missouri
11	Arkansas-White-Red
12	Texas Gulf
13	Rio Grande
14	Upper Colorado
15	Lower Colorado
16	Great Basin
17	Pacific Northwest
18	California

West of the Appalachians lies a vast interior lowland that covers nearly half of the conterminous United States. It includes the drainage of the Mississippi River and its two major tributaries, the Ohio and Missouri rivers. The Mississippi River is the principal feature of this lowland, forming a major north-south waterway into the heartland of the United States. The lowland includes a wide coastal plain bordering the Gulf of Mexico, with rolling hills, river valleys, and extensive prairies lying north of the coastal plain. Dense deciduous woodlands originally covered the eastern portion of the lowland, transitioning to pine forests in the south. Further west, the woodland gives way to prairie, a vast grassland mostly devoid of trees. Much of the woodland and prairie has been converted to agricultural use. The climate ranges from warm in the south to cold in the north, with precipitation decreasing toward the west.

A complex series of high mountain ranges, valleys, canyons, and plateaus create a spectacular landscape in the western United States. The Great Plains, which form the western portion of the interior lowlands, gradually rise thousands of feet in elevation to meet the abrupt eastern front of the Rocky Mountains. The Rocky Mountains are a chain of high mountain ranges extending from Mexico through the western United States into Canada. The crest of the Rocky Mountains form the continental divide. Streams east of the continental divide flow to the Atlantic Ocean, the Gulf of Mexico and Hudson Bay. Most streams west of the continental divide flow to the Pacific Ocean or to the Gulf of California. However, streams in many areas west of the continental divide discharge into saline lakes or mud flats. These streams remain within the Great Basin, a series of semi-arid to arid mountains, valleys, and plains with no outlet to the sea. More high mountains are found in the West Coast states: the Cascades in Washington and Oregon and the Sierra Nevada in California. An additional set of mountain ranges, known as the Coast Ranges borders the Pacific coastline of these three states.

The landscape varies greatly in the West. Cool, damp rainforests cover the slopes of the Coast Ranges in the Pacific Northwest. The Cascades and the Sierra Nevada have extensive coniferous forests due to abundant Pacific moisture. However, these ranges create a rain shadow that forms dry steppes and deserts immediately to their east. The two major rivers of the West, the Columbia River and the Colorado River, have been extensively developed for hydropower. The Grand Coulee Dam in Washington and the Hoover Dam on the Nevada-Arizona border are the best known of the West’s hydropower mega-projects. Interior valleys have fertile soils suitable for farming, including the Great Central Valley of California, the Willamette Valley of Oregon, and the Snake River Plain in Idaho. In many places irrigation water from mountains or rivers is imported to water crops in arid areas. Water is also imported for hundreds of miles to supply the domestic needs of major coastal cities in California.

3. TECHNICAL APPROACH

The fundamental approach of this study was to calculate the hydropower potential of mathematical analogs of every stream reach within each of the hydrologic regions in the study area. A stream reach was generally the stream segment between two confluences and had an average length of 2 miles. After producing a master set of reach power potentials, this set was validated using data from the National Hydrography Dataset (NHD). The validated version of the master dataset was filtered to account for waterways excluded from development. No other feasibility assessments were performed. Additional filtering produced subsets corresponding to various power classes; one of which was low head/low power. The low head/low power class was further filtered to produce subsets based on the operating envelopes of three classes of low head/low power hydropower technologies. Summing the resulting subsets of reach power potentials produced total power potentials of interest. Developed hydropower in the region was deducted in the process of determining "available" power potentials. (Note: The term "available power potential" in this report simply equates to total power potential minus the sum of developed power potential and excluded power potential with no assessment of economic or development feasibility.)

The calculation of reach hydropower potential requires two values: the reach flow rate and the hydraulic head corresponding to the elevation difference between the upstream and downstream ends of the reach. The reach flow rate was the average of the calculated flow rates at the inlet and outlet of the reach. The flows were calculated using a regression equation in which drainage area, mean annual temperature, and mean annual precipitation were the independent variables. The reach hydraulic head was derived from the hydrography as defined by a digital elevation model.

The subsections that follow describe the details of the various aspects of the technical approach as applied to each hydrologic region:

- Calculation of reach hydropower potential

- Filtering processes to validate streams, account for excluded waterways, and parse potentials between power classes and classes of low head/low power hydropower technologies

- Determination of available hydropower potential accounting for developed hydropower potential.

It further describes how total hydropower potential values of interest were determined for individual states and for the entire conterminous United States study area.

3.1 Calculation of Stream Flow, Hydraulic Head, and Hydropower Potential

The calculation of the stream flow rate, hydraulic head, and subsequently, hydropower potential requires a three-dimensional representation of the hydrography and related drainage basin information. The three-dimensional hydrography provides the extent of stream networks and the elevation differences required to calculate hydraulic heads. Related drainage basin information provides essential data for the calculation of stream flow rates. While the National Hydrography Dataset (NHD) provides the best two-dimensional depiction of the United States hydrography, it does not provide the required elevation information or related drainage basin information. In order to obtain the required hydrography parameters, the Elevation Derivatives for National Applications (EDNA) dataset was used. This dataset provided the needed three-dimensional hydrography in the form of analytically derived stream networks with associated elevation values and drainage areas associated with each stream reach that could be summed to produce the drainage basin supplying runoff to points of interest along a stream.

A graphical illustration of the hydrography related information provided by the EDNA dataset is shown in Figure 2. This figure shows synthetic stream reaches each with an associated, local runoff area or catchment shown as a colored area

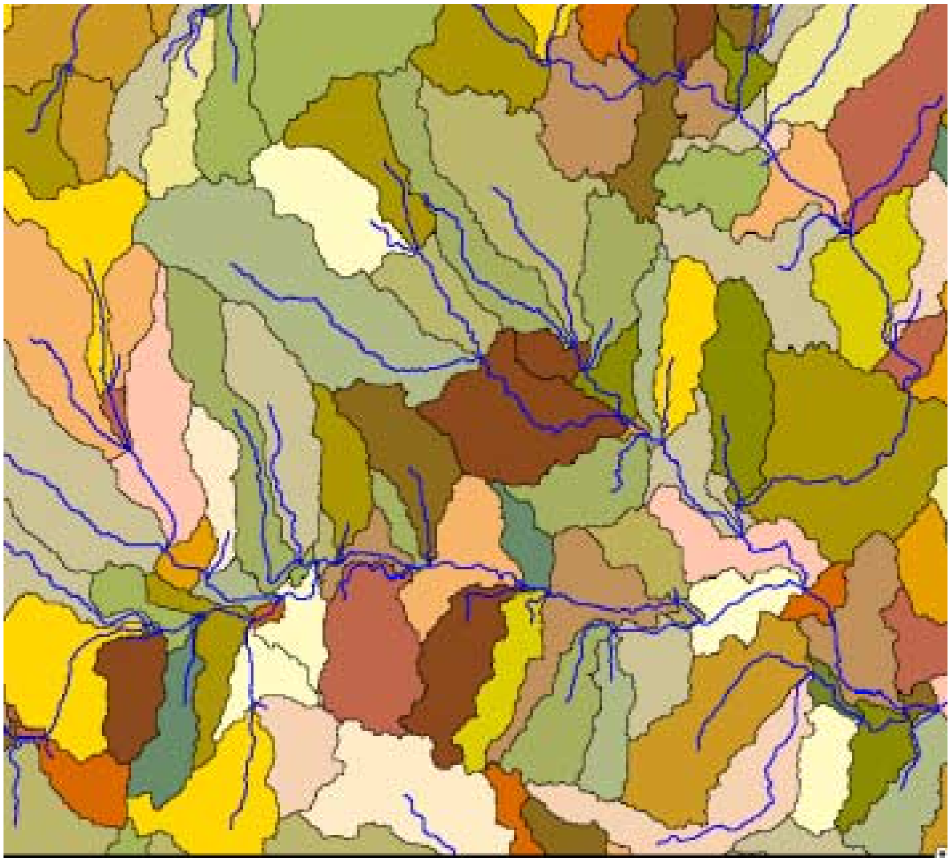

Figure 2. EDNA-derived catchments and synthetic streams.

encompassing the reach. Flow rate was calculated at the downstream end of each reach, which has been termed the catchment “pour point.” The drainage area supplying runoff to a pour point is equal to the sum of the areas of all the upstream catchments, including that of the local catchment.

Average annual mean flow rates were calculated using regression equations developed specifically for each hydrologic region (Vogel et al. 1999). These equations are of the form:

$$Q = e^{a} * A^{b} * P^{c} * T^{d}$$

where

Q = annual mean flow rate in cubic meters/second

A = drainage area in square kilometers

P = mean annual precipitation in millimeters/year

T = mean annual temperature in degrees Fahrenheit times 10.

The region-specific exponents are listed in Table 2.

These equations are based on gaged stream flows within the regions. The drainage area used is the sum of the upstream catchment areas. The other two variables, mean annual precipitation and mean annual temperature, were derived from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) dataset (Daly et al. 1994). Both temperature and precipitation data contained in the PRISM dataset are in grid format. The cells of the grids are much larger than grid cells on which the EDNA dataset is based (30 × 30 m); therefore, an averaging function was used to calculate the mean annual precipitation and mean annual temperature for each catchment in the

Table 2. Exponents for regional annual mean flow rate regression equations by hydrologic region.

Region (HUC)	Name	Exponents a	b	c	d
1	North Atlantic	-9.4301	1.01238	1.21308	-0.5118
2	Mid-Atlantic	-2.7070	0.97938	1.62510	-2.0510
3	South Atlantic-Gulf	-10.1020	0.98445	2.25990	-1.6070
4	Great Lakes	-5.6780	0.96519	2.28890	-2.3191
5	Ohio	-4.8910	0.99319	2.32521	-2.5093
6	Tennessee	-8.8100	0.96418	1.35810	-0.7476
7	Upper Mississippi	-11.8610	1.00209	4.55960	-3.8984
8	Lower Mississippi	0.0000	0.98399	3.15700	-4.1898
9	Souris-Red-Rainy	0.0000	0.81629	6.42220	-7.6551
10	Missouri	-10.9270	0.89405	3.20000	-2.4524
11	Arkansas-White-Red	-18.6270	0.96494	3.81520	-1.9665
12	Texas Gulf	0.0000	0.84712	3.83360	-4.7145
13	Rio Grande	0.0000	0.77247	1.96360	-2.8284
14	Upper Colorado	-9.8560	0.98744	2.46900	-1.8771
15	Lower Colorado	0.0000	0.8663	2.50650	-3.4270
16	Great Basin	0.0000	0.83708	2.16720	-3.0535
17	Pacific Northwest	-10.1800	1.00269	1.86412	-1.1579
18	California	-8.4380	0.97398	1.99863	-1.5319

EDNA data. The catchment temperature and precipitation values were used to produce an area-weighted value for each drainage area. These values along with the drainage area were used to calculate the flow at the pour point of each catchment (downstream end of a reach).

The hydraulic head associated with each stream reach was obtained using the elevation data in the EDNA dataset. The dataset provided the elevation at the upstream and downstream ends of the reach. The difference of these two elevation values was the hydraulic head for the flow in the reach. While this was the correct value for the flow that entered the reach at the upstream end and transited the reach converting potential to kinetic energy, it was not the correct value for the portion of the flow at the reach exit or downstream end that was contributed by runoff from the local catchment. This added flow had hydraulic heads varying from the total reach hydraulic head to zero depending on where the runoff entered the stream. To account for this, the following equation was used to calculate the hydropower potential of the reach:

$$P = \kappa\, [Q_i * H + (Q_o - Q_i) * H/2];\ H = z_i - z_o$$

where

P = power in kilowatts

κ = equals (1/11.8)

Q_i = flow rate at the upstream end of the stream reach in cubic feet per second

Q_o = flow rate at the downstream end of the stream reach in cubic feet per second

H = hydraulic head in feet

z_i = elevation at the upstream end of the stream reach in feet

z_o = elevation at the downstream end of the stream reach in feet.

The first quantity in the square brackets, $Q_i * H$, is the hydropower potential of the flow that enters and transits the entire reach. This flow experiences the full hydraulic head of the reach, H (difference between elevations at upstream and downstream ends of the reach). The quantity

$(Q_o - Q_i)$ is the part of the reach flow added by runoff from the associated catchment. For this flow, the hydraulic head varies from H to 0 depending on where runoff entered the reach. Therefore, an average value of H/2 was used for the local catchment runoff flow.

Algebraic manipulation shows that this equation reduces to:

$$P = \kappa H(Q_i + Q_o)/2$$

Thus, the reach hydropower potential is equal to a constant times the total reach hydraulic head times the average of the flow rates at the inlet (upstream end) and the outlet (downstream end) of the reach. It is also useful to note that Q_o is the pour point flow for the catchment associated with the reach, and Q_i is equal to the sum of the pour point flows of the catchments immediately upstream of the reach (catchment) of interest.

The calculations described above produced a master dataset containing the following parameters for each stream reach:

- Reach characteristics
- Related catchment characteristics
- Reach outlet flow (catchment pour point flow)
- Reach hydraulic head
- Reach hydropower potential.

This master dataset was subsequently filtered to:

1. Remove stream reaches that were not validated using the NHD
2. Identify reaches that were excluded from development because of statutory protections
3. Identify reaches having hydropower potentials within various power classes
4. Divide low head/low power reaches into three subsets corresponding to the operating envelopes of three classes of low head/low power hydropower technologies.

These filtering operations are described in detail in the subsections that follow.

The accuracy of the hydropower potential estimates is dependent on the accuracy of the individual stream reach hydropower potentials that were summed to produce total values of interest. The calculated reach flow rates had standard errors ranging from ±9% to ±96%. The standard errors of the calculated flows for each hydrologic region are given in Table 3.

Table 3. Standard errors of calculated flow rates in percent by hydrologic region.

Region (HUC)	Name	Mean Std Error (±%)
1	North Atlantic	9
2	Mid-Atlantic	12
3	South Atlantic-Gulf	17
4	Great Lakes	16
5	Ohio	12
6	Tennessee	14
7	Upper Mississippi	14
8	Lower Mississippi	15
9	Souris Red-Rainy	37
10	Missouri	63
11	Arkansas-White-Red	31
12	Texas Gulf	61
13	Rio Grande	55
14	Upper Colorado	44
15	Lower Colorado	96
16	Great Basin	53
17	Pacific Northwest	36
18	California	51

Because of the direct relationship of hydropower potential and flow rate, the standard error of the reach hydropower potential values was also at least ±9% to ±96%. If the errors are uniformly distributed, the accuracy of a total value produced by summing a large number of reach hydropower potentials may be better than the accuracy associated with the values that were summed.

3.2 Validation of Synthetic Streams

The U.S. Geological Survey performed the processing that produced the Stage 1B version of the EDNA dataset in a consistent manner nationwide. It generally works well for areas having moderate to high relief and well-developed drainage. In certain types of terrain, however, the EDNA Stage 1B processing can create synthetic hydrography that deviates substantially from the actual hydrography.

Figure 3 shows an overlay of EDNA synthetic streams and hydrography taken from the NHD for part of the study area. It is clear from this comparison that some of the synthetic stream reaches are not validated by the NHD and must be removed so as not to inflate the total hydropower potential estimate. To identify these “false” synthetic stream reaches and determine their effect on the regional, total hydropower potential, known stream locations found in the NHD were intersected with the catchments associated with EDNA synthetic streams. This allowed the stream reaches in the master dataset to be coded effectively, creating two subsets: one containing all the reaches whose catchments contained an NHD stream segment and one containing all the reaches whose catchments did not contain an NHD stream segment. The former was considered to be a validated master dataset, while the latter was a dataset containing all the “false” stream reaches. Figure 3 illustrates false stream reaches, which show through in red in contrast to the NHD reaches shown in blue. While this approach did not guarantee exact conflation of the EDNA synthetic streams with the NHD hydrography, it did ensure that an NHD stream segment existed within the catchment area, averaging 3 square miles, that encompasses the synthetic reach.

In order to evaluate the effect of the “false” stream reaches on total hydropower potential, the hydropower potentials of the reaches in the false reach dataset were summed and compared to the sum of the hydropower potentials of all the stream reaches in the master dataset. It was found that 2.7% of the total potential power calculated for the conterminous United States using all the stream reaches is due to false stream segments, leaving 97.3% of the original total hydropower potential in the validated master dataset.

3.3 Identification of Stream Reaches Excluded from Hydropower Development

As a general rule, hydropower development is prohibited in certain protected areas, such as national parks, national monuments, or along federally designated wild and scenic rivers. Protected areas such as these were designated as “exclusion areas.” Catchments that overlap any portion of these “exclusion areas” were designated as “excluded catchments.” The total hydropower potential associated with the stream reaches in these excluded catchments was calculated and was subsequently subtracted from the total hydropower potential, so that it would not contribute to available hydropower potential.

3.3.1 Types of Excluded Areas

Two geographic information system (GIS) data layers from the National Atlas of the United States were used to locate exclusion areas. The first layer, “Federal and Indian Lands,” contains the boundaries of all federal lands in the United States, subdivided into categories such as national parks, national monuments, Indian reservations, military bases, and DOE sites. The second layer, “Parkways and Scenic Rivers,” contains federally protected linear features such as National Wild and Scenic Rivers and National Parkways. Both GIS data layers are available online from the National Atlas of the United States website at *http://www.nationalatlas.gov/atlasftp.html*.

The two above-mentioned GIS data layers provide comprehensive nationwide information regarding federally protected lands. States, regional jurisdictions, and local jurisdictions have also designated protected areas that are most likely excluded from hydropower development. However, information regarding these protected areas is scattered among numerous state, regional, and local government agencies. Much of this information is not yet in digital format, and much of the digital data are not available online.

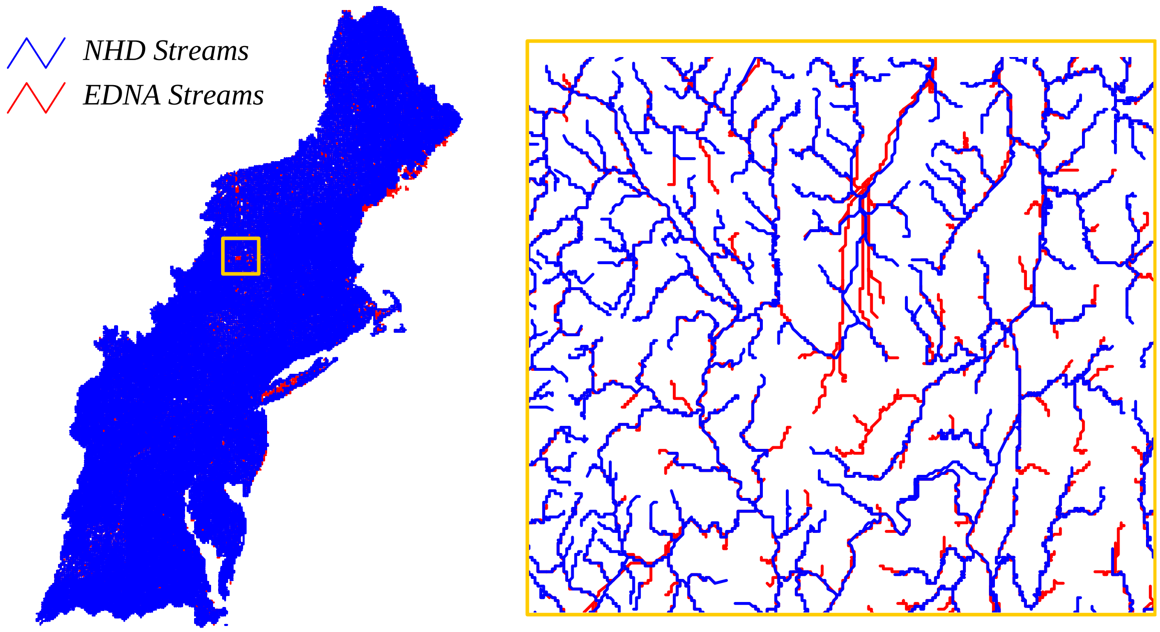

Figure 3. NHD streams overlaying EDNA synthetic streams in the study area.

Determining the boundaries of lands protected by nonfederal agencies would have entailed contacting a large number of agencies within the study area and collecting and digitizing multiple paper datasets in a variety of formats. Such an effort was beyond the scope of the project. Therefore, only nationwide datasets of federally protected lands and rivers were used to determine the extent of exclusion areas.

The categories of federal lands listed in the GIS dataset "Federal and Indian Lands" were reviewed to determine categories corresponding to areas in which hydropower development is highly likely to be excluded. Based on this review, the following categories of federal lands were selected as exclusion areas:

- National battlefields
- National historic parks
- National parks
- National parkways
- National monuments
- National preserves
- National wildlife refuges
- Wildlife management areas
- National wilderness areas.

All the federal lands in these categories were used to create an "excluded federal lands" GIS data layer. Similarly, all national wild and scenic rivers were extracted from the National Wild and Scenic Rivers and National Parkways data layer to create a GIS data layer composed exclusively of Wild and Scenic Rivers. Because the "wild and scenic rivers data layer" contained only the rivers themselves, but no adjoining land, all land within one kilometer of a wild and scenic river reach was designated as an excluded area. These areas were combined with excluded federal lands to create a final "excluded area" GIS data layer that contains the boundaries of all lands and shorelines excluded from hydropower development.

3.3.2 Methodology for Identifying Excluded Stream Reaches

The final excluded area data layer was intersected with the catchment data layer of the master dataset to identify catchments containing stream reaches that should be excluded from consideration as sources of potential hydropower. The stream reaches in the master dataset were thus coded as being either excluded or not excluded from hydropower development.

3.4 Determining Developed Hydropower Potential

Determining the amount of hydropower potential within a study area that is possibly available for development requires estimating how much hydropower potential has already been developed. Use of total developed hydropower capacity within the study area as provided by the FERC's *Hydroelectric Power Resources Assessment (HPRA) Database* (FERC 1998) significantly overestimates the developed potential. Plant capacities are selected by the designer based on anticipated flow rates, which may not be natural stream flows, economic considerations, and other factors and may be a factor of two or more higher than the average power based on average flow rate and hydraulic head where the plant is located.

In order to produce an estimate of the developed hydropower potential that is comparable to the potential estimates based on average annual mean flow rates, it was necessary to estimate the average rate at which energy was generated by each hydroelectric plant and by the aggregate of plants in the region. An estimate of this value is obtained by dividing the average annual generation of the plant or plants as listed in the HPRA Database by the total hours in a year (8,760 hr). Table 4 lists the total developed hydropower potential for each of the 18 hydrologic regions along with the total average annual electric generation from which it was derived, the total regional hydropower capacity, and the number of plants in the region as provided by the 1998 version of the HPRA Database.

A dataset containing developed hydropower potential for each plant and the plant's geographic coordinates from the HPRA Database was intersected with two GIS layers. The first intersection was with the exclusion area layer described in Subsection 3.3. This allowed each

Table 4. Developed hydropower potential by hydrologic region.

Region (HUC)	Name	Average Annual Mean Power (Developed Potential) (MW)	Average Annual Generation (MWh)	Developed Capacity (MW)	Number of Plants
1	North Atlantic	873	7,648,312	1,881	397
2	Mid-Atlantic	840	7,359,758	2,060	206
3	South Atlantic-Gulf	1,849	16,195,998	6,743	165
4	Great Lakes	2,852	24,987,042	4,092	288
5	Ohio	820	7,182,482	1,772	48
6	Tennessee	1,859	16,282,814	3,855	55
7	Upper Mississippi	404	3,543,100	734	119
8	Lower Mississippi	136	1,192,680	398	6
9	Souris Red-Rainy	13	110,058	22	8
10	Missouri	1,797	15,743,664	3,722	80
11	Arkansas-White-Red	696	6,100,625	2,097	33
12	Texas Gulf	127	1,115,557	428	23
13	Rio Grande	50	441,821	157	7
14	Upper Colorado	724	6,339,303	1,882	41
15	Lower Colorado	790	6,916,259	2,556	23
16	Great Basin	98	854,819	228	81
17	Pacific Northwest	16,676	146,085,711	32,365	339
18	California	4,674	40,943,253	9,450	413
	Totals	**35,279**	**309,043,256**	**74,442**	**2,332**

of the developed potentials to be coded as to whether it was inside or outside an exclusion area. (The total developed hydropower potential corresponding to plants located in an exclusion area was subsequently subtracted from the total hydropower potential located in exclusion areas to avoid double counting as discussed in Subsection 3.6.3.) The second intersection was with the GIS layer containing the state boundaries. This allowed each of the developed hydropower potentials to be coded with the state name in which it is located. Standard database query techniques were used to parse the developed hydropower potentials into power and technology classes and calculate totals for each class. The power classes and how the various totals of developed hydropower potential were used to produce hydropower potential totals of interest are described in the next subsection.

While the approach used to estimate developed hydropower potential produces values that are comparable to the estimated values of total hydropower potential, the developed potential estimates are recognized not to be perfectly comparable. The electricity generation figures on which developed values are based are actual average generation values rather than ideal values like the total hydropower potential estimates. The actual values are less than ideal because of plant efficiency and outages. However, using average annual generation to estimate developed potential is significantly better than using developed capacity figures; although, it leads to nonconservative values of available potential.

3.5 Identification of Stream Reaches by Power and Technology Class

Stream reaches in the validated master dataset described in Subsection 3.2 with exclusion coding as described in Subsection 3.3 were filtered into three basic power classes and the operating envelopes of three classes of low head/low power technologies using standard database query techniques with power and hydraulic head as the selection criteria. The three basic power classes are:

- High head/high power
- Low head/high power
- High head/low power

where high power refers to ≥1 MW, low power refers to <1 MW, high head refers to ≥30 ft, and low head refers to <30 ft.

The boundary between the high power and low power classes defined by hydraulic head and flow rate is shown graphically in Figure 4.

The low head/low power class is defined by the following two criteria:

- All hydropower potential less than 100 kW (microhydro)
- Hydropower potential greater than or equal to 100 kW but less than 1 MW with hydraulic head less than 30 ft.

The low head/low power class shown in Figure 4 is divided into the operating envelopes of three classes of low head/low power technologies:

- Microhydro technologies—Power less than 100 kW
- Conventional turbines—Power greater than or equal to 100 kW, but less than 1 MW AND hydraulic head less than 30 ft, but greater than or equal to 8 ft
- Unconventional systems—Power greater than or equal to100 kW, but less than 1 MW AND hydraulic head less than 8 ft.

These operating envelopes are shown graphically in Figure 5.

3.6 Calculation of Total Hydropower Potentials of Interest

Regional hydropower potential totals of interest were calculated by summing the reach hydropower potentials within each of the three basic power classes and the three operating envelopes described in the previous subsection.

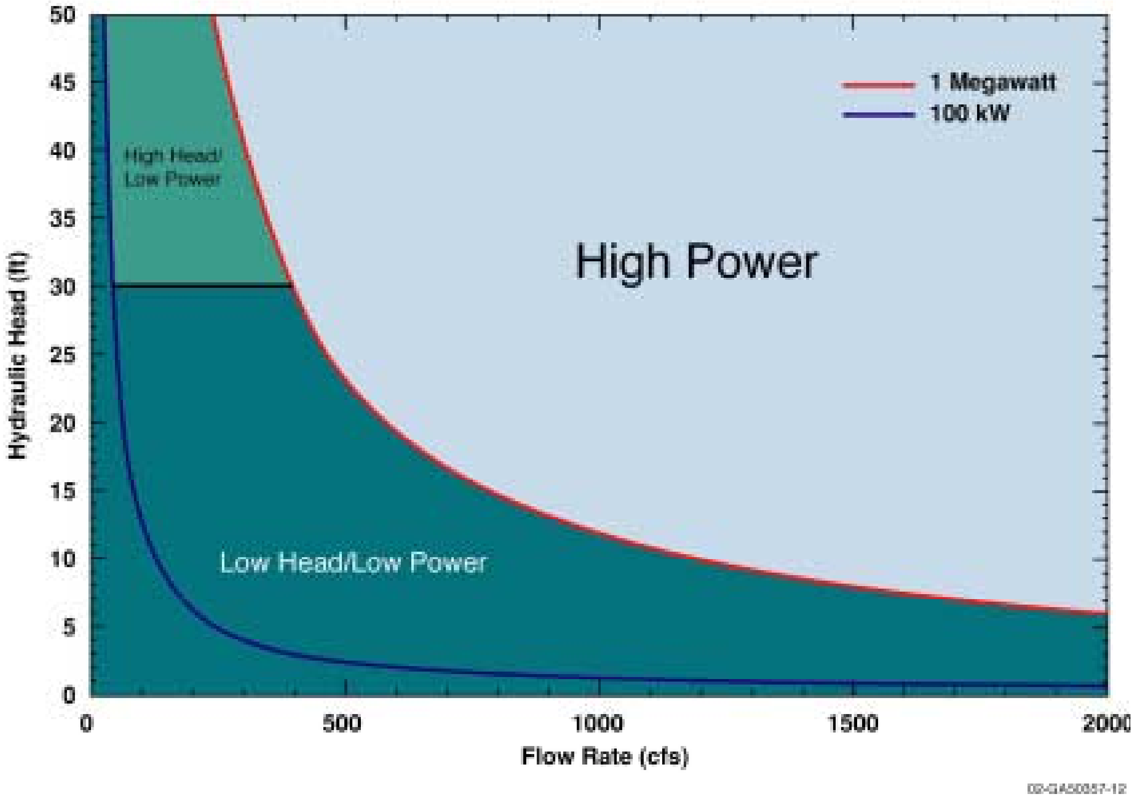

Figure 4. Boundaries of the high power and low power classes.

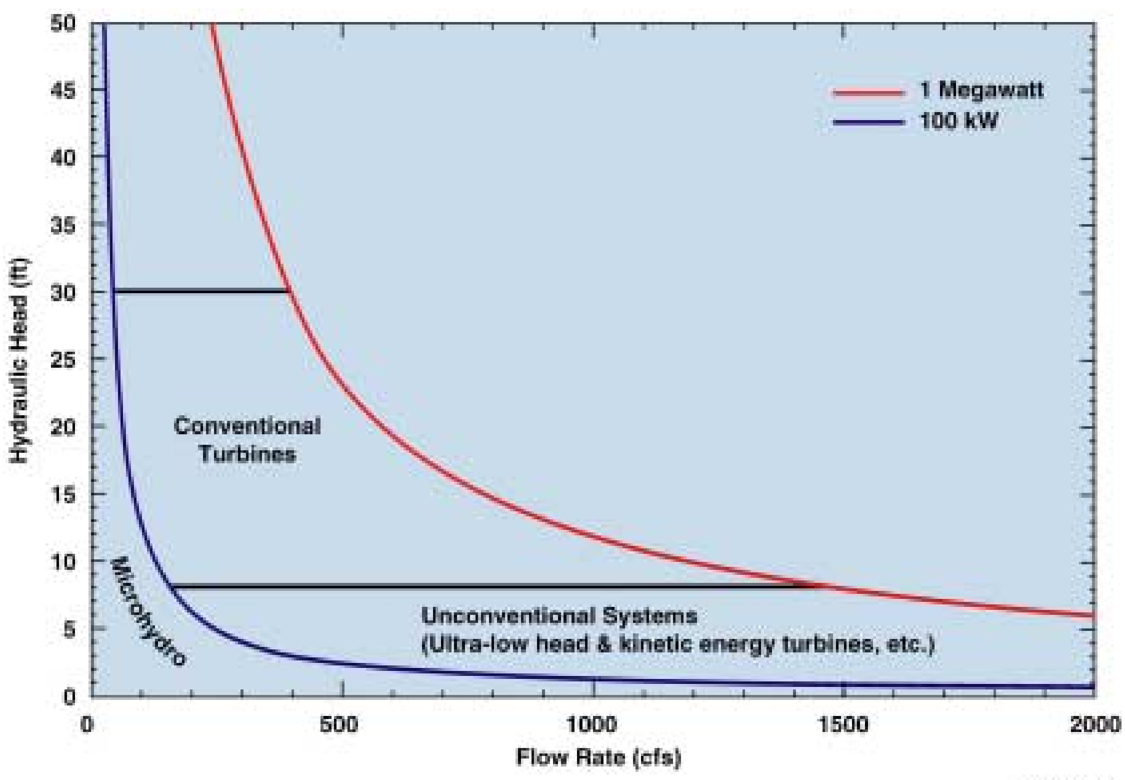

Figure 5. Operating envelopes of three classes of low head/low power hydropower technologies.

Two sums were obtained for each: one using the stream reaches that were coded as excluded and one for the stream reaches coded as nonexcluded. These totals of hydropower potential were used to determine total hydropower potential in four power categories (total, developed, excluded, and available) for each of seven power classes and the three low head/low power hydropower technology classes as described below.

3.6.1 Total Hydropower Potential

The total hydropower potential for each of the three basic power classes and the three technology classes described in the previous subsection were calculated by adding the excluded and nonexcluded hydropower potential totals for each power and technology class. The total hydropower potential for four additional power classes (low head/low power, low power, high power and total power) were obtained by rolling up constituent parts as follows:

Low Head/Low Power = ΣTechnology Classes

Low Power = High Head/Low Power + Low Head/Low Power

High Power = High Head/High Power + Low Head/High Power

Total Power = High Power + Low Power.

3.6.2 Total Developed Hydropower Potential

Total developed hydropower potential for each power and technology class was determined by querying the dataset of developed hydropower potentials using power and hydraulic head selection criteria corresponding to the boundaries of the various power and technology classes. Summing the selected data produced the values for each class.

3.6.3 Total Excluded Hydropower Potential

Total excluded hydropower potential in each power class was determined using the same process as described for Total Hydropower Potential in Subsection 3.6.1 except in this case only the sums of excluded stream reach power potentials were used. In order to avoid double counting, the total of the developed power potentials for each of the three basic power classes and three technology classes that are located in exclusion areas were subtracted from the total excluded hydropower potential for each power/technology class.

3.6.4 Total Available Hydropower Potential

The total available hydropower potential in each power class and for each technology class was calculated using the total, developed, and excluded hydropower potentials for the power or technology class using the equation:

AHP = THP − DHP − EHP

where

AHP = Available Hydropower Potential

THP = Total Hydropower Potential

DHP = Developed Hydropower Potential

EHP = Excluded Hydropower Potential.

3.7 Total Hydropower Potentials for Each State

Total hydropower potentials like those determined for each hydrologic region were produced for each of the 48 states in the conterminous United States. In order to obtain values for the states, a GIS layer containing the state boundaries was intersected with the validated master dataset of stream reaches. This allowed the stream reaches to be coded by the state in which they are located. The database queries and summing described in Subsections 3.5 and 3.6 were performed using the state name as an additional selection criterion.

3.8 Total Hydropower Potentials for the Conterminous United States

The conterminous United States total hydropower potentials for the various power and technology classes in the four power categories were calculated by summing the corresponding state values. The state rather than regional values were used for two reasons. First, the state boundaries were more precise in defining the boundaries of the conterminous United States. Second, because the states were smaller areas than the regions, they showed instances in which the sum of the developed and excluded hydropower potential exceeded the total hydropower potential resulting in negative available hydropower potential values that were not realistic. This occurred in the high head/high power class for six states: Florida, Iowa, Nebraska, Nevada, North Dakota, and South Dakota. The negative availability values are attributable to one or a combination of underestimating of the total hydropower potential and overestimating the developed hydropower potential. Because the negative available potential values were not realistic, they were set equal to zero. For these states, the available hydropower potential for the high power class is equal to the available potential in the low head/high power class, and the total available potential is the sum of the high power and low power class values. For the available potentials calculated this way, available potential is not equal to total potential minus the sum of the developed and excluded values.

Negative excluded hydropower potential values also occurred in the high head/high power class for two of these states: Nevada and South Dakota. The negative values are attributable to one or a combination of underestimating the amount of excluded potential and overestimating the amount of developed potential in exclusion areas. The unrealistic negative values were set to zero, and thus, the high power excluded potential value was equal to the low head/high power excluded value.

4. RESULTS

The results of the assessment process described in the previous section are presented with emphasis on four power classes:

- Total power
- High head/low power
- Low head/low power
- Low head/low power by technology

and the three classes of low head/low power technologies.

Table 5 presents a summary of the results for the conterminous United States. These results are discussed in the subsections that follow.

4.1 Total Hydropower Potential

The sum of all the validated reach hydropower potentials in all 18 regions and the corresponding 48 states provided an estimate of 200,407 MW of hydropower potential in the conterminous United States. The developed hydropower potential corresponding to the 2,332 hydroelectric plants in the study area totals 35,279 MW. The total hydropower potential of stream reaches excluded from development is 45,878 MW. Subtracting the developed and excluded hydropower potentials from the total provides an estimate of 119,250 MW of hydropower that has not been developed and is not excluded from development. This estimate has been revised upward to 119,937 MW to correct for six states having unrealistic negative amounts of available hydropower potential.

These hydropower potential values have significant uncertainties because of the uncertainties associated with the flow rate estimates and nonconformances between the synthetic and the actual hydrography. However, they represent more comprehensive, order of magnitude estimates than have previously been achieved. Additional exclusions by state agencies that were beyond the scope of the project to research would most certainly reduce the amount of available hydropower potential. The number would no doubt be further significantly reduced based on engineering and economic feasibility assessments of specific sites, which were not performed.

The distribution of total hydropower potential between developed, excluded, and available power is shown graphically in Figure 6. This figure

Table 5. Summary of results of hydropower resource assessment of the conterminous United States.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**200,407**	**35,279**	**45,878**	**119,937**
TOTAL HIGH POWER	**155,025**	**35,113**	**40,198**	**80,401**
High Head/High Power	**109,855**	**34,100**	**32,779**	**43,663**
Low Head/High Power	**45,170**	**1,013**	**7,419**	**36,738**
TOTAL LOW POWER	**45,382**	**166**	**5,680**	**39,536**
High Head/Low Power	**25,005**	**87**	**4,480**	**20,438**
Low Head/Low Power	**20,377**	**79**	**1,200**	**19,098**
Conventional Turbine	7,049	74	378	6,597
Unconventional Systems	3,247	1	256	2,990
Microhydro	10,081	4	566	9,511

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

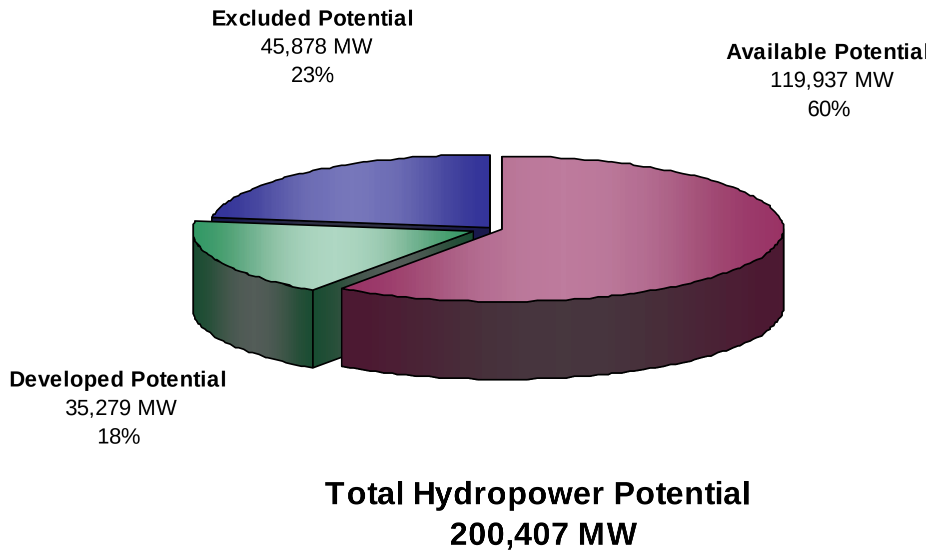

Figure 6. Constituents of total hydropower potential in the conterminous United States.

shows that only 18% of the total hydropower potential has been developed. The hydropower potential excluded by federal statute and policy is 23% leaving 60% of the potential in the conterminous United States available for possible development.

4.2 Available Hydropower Potential by Power Class

The division of the total, available hydropower potential (≈120,000 MW) between the high power (greater than or equal to 1 MW), high head/low power (power less than 1 MW and hydraulic head of 30 ft or more, excluding the microhydro operating envelope), and low head/low power (power less than 1 MW and hydraulic head less than 30 ft and including the microhydro operating envelope) is shown graphically in Figure 7. This figure shows that slightly less than 70% of the available hydropower potential is in the high power class (≈80,000 MW) and slightly more than 30% is in the low power class (≈40,000 MW). The available hydropower potential in the low power class is split approximately equally between high head (30 ft or greater) potential (17% of the available potential) and low head (less than 30 ft) potential (16% of the available potential). Considering the amount of available hydropower potential in the high power and high head/low power classes and that in the conventional turbines technology class (discussed in Subsection 4.3) shows that 90% of the available hydropower potential could be captured by conventional turbine technology not requiring additional turbine research and development. However, deployment of the existing turbine technology to capture particularly the low head portion of the potential will likely require research and development of new system configurations.

4.3 Low Head/Low Power Potential

The sum of all the validated reach hydropower potentials having values that fell within the low head/low power class shown in Figure 4 provided an estimate of approximately 20,000 MW of low head/low power hydropower potential in the study area. The developed hydropower potential that fell within the low head/low power regime amounts to 79 MW. The total hydropower potential of the reaches that were both low head/low power and were excluded from development was 1,200 MW. Subtracting the developed and excluded hydropower potentials from the total low head/low power potential provides an estimate of about 19,000 MW of low head/low power hydropower that has not been developed and is not excluded from development. As mentioned in the previous subsection, this figure would be reduced by

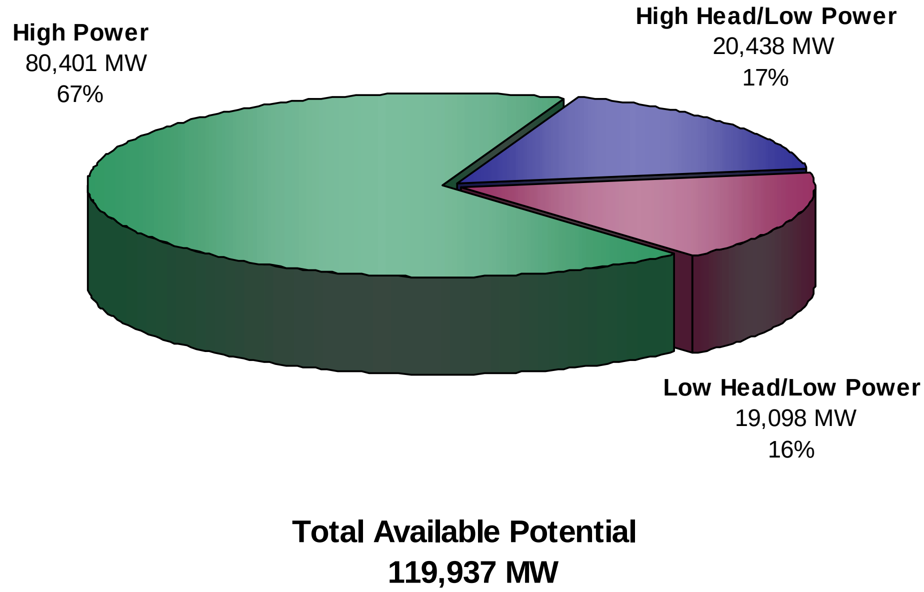

Figure 7. Constituents of available hydropower potential in the conterminous United States.

exclusions by state agencies and elimination of sites as the result of feasibility assessments.

The validated reach hydropower potentials having values that fell within each of the operating envelopes of the three classes of low head/low power hydropower technologies shown in Figure 5 were summed to provide an estimate of the total hydropower potential associated with each technology class. This resulted in estimates of 7,049 MW, 3,247 MW, and 10,081 MW of hydropower potential for conventional turbines, unconventional systems, and microhydro technologies, respectively. The total hydropower potentials that were either developed or excluded from development and corresponded to each of the operating envelopes were 452 MW, 257 MW, and 570 MW, respectively. Subtracting the developed and excluded potentials from the total potential for each technology class resulted in estimates of available hydropower potential of 6,597 MW, 2,990 MW, and 9,511 MW, respectively. While these availability estimates will be reduced because of exclusions by state agencies and feasibility assessments, it should be considered that portions of high power resources may be diverted to or be partially captured by low power technologies making their possible hydropower potentials higher than the values obtained considering only their operational boundaries.

The distribution of low head/low power hydropower potential among the three classes of technologies is shown in Figure 8. This figure shows that 35% of the available low head/low power hydropower potential is captured by the operating envelope of conventional turbines. Half (50%) is captured by the operating envelope of microhydro technologies. The remaining 15% corresponds to unconventional systems.

The geographic locations of existing hydroelectric plants and high head/low power hydropower potential sites are shown in Figure 9. Similarly, the geographic locations of low head/low power hydropower potential sites are shown in Figure 10. In this figure, different color symbols are used to designate sites of hydropower potential corresponding to each of the three classes of low head/low power technologies. Areas in which hydropower development is excluded because of federal statutes and policies are shown in both maps. The maps are intended to show the relative density of hydropower potential. The symbols are larger than the actual extent of the stream reach containing the potential they designate, so that the density of symbols gives a distorted image of the actual density of the stream reaches.

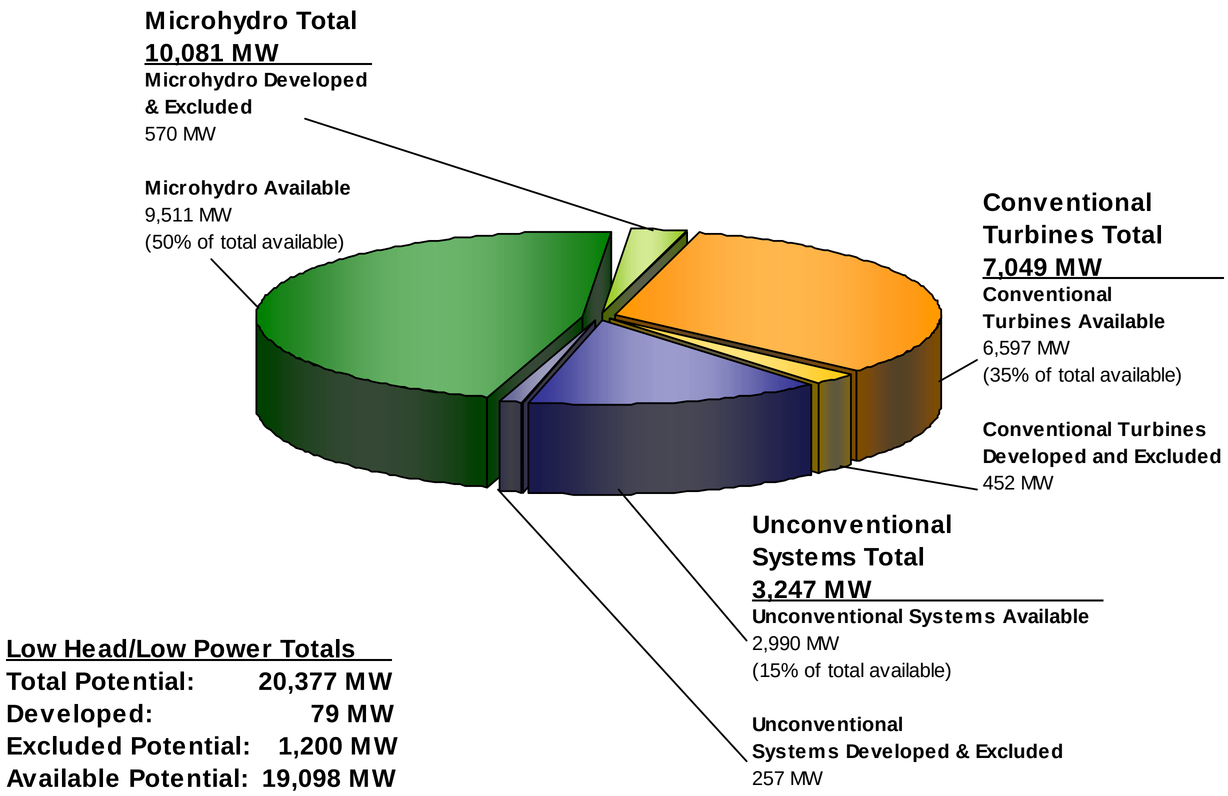

Figure 8. Low head/low power hydropower potential in the conterminous United States divided among three low head/low power hydropower technology classes.

High head/low power potential is abundant in the mountainous areas of the country as shown in Figure 9. Conventional turbine and unconventional systems sites are numerous and well dispersed in the eastern half of the country and northern Pacific coast as shown in Figure 10. This figure also shows that microhydro sites are density distributed throughout the country with the exceptions of the central plains and other areas that have very small variations in elevation, the most arid parts of the country, and areas dominated by resources in other power and technology classes.

4.4 Comparison of Regional Hydropower Potentials

The total hydropower potentials of the 18 hydrologic regions subdivided into developed, excluded, and available constituents are compared in Figure 11 by presenting them in ascending order of total hydropower potential. The Pacific Northwest Region contains by far the largest total potential with its 76,000 MW of potential, which is approximately 40% of the total hydropower potential of the conterminous United States. The potential of this region is nearly three times that of the region with the second highest potential, the California Region with 27,000 MW of potential. These two regions have the largest developed, excluded, and available potentials of all the regions with the exception of available potential where the Lower Mississippi Region has more than the California Region.

Regions other than the Pacific Northwest and the California Regions have higher percentages of developed and available potential. Noteworthy with regard to percentage of developed power are the Great Lakes Region (66%) and the Tennessee Region (37%) compared to the next highest regions: Lower Colorado (23%), Pacific Northwest (22%), South Atlantic-Gulf (21%), and California (17%). From the perspective of available potential percentages, eight regions have outstanding

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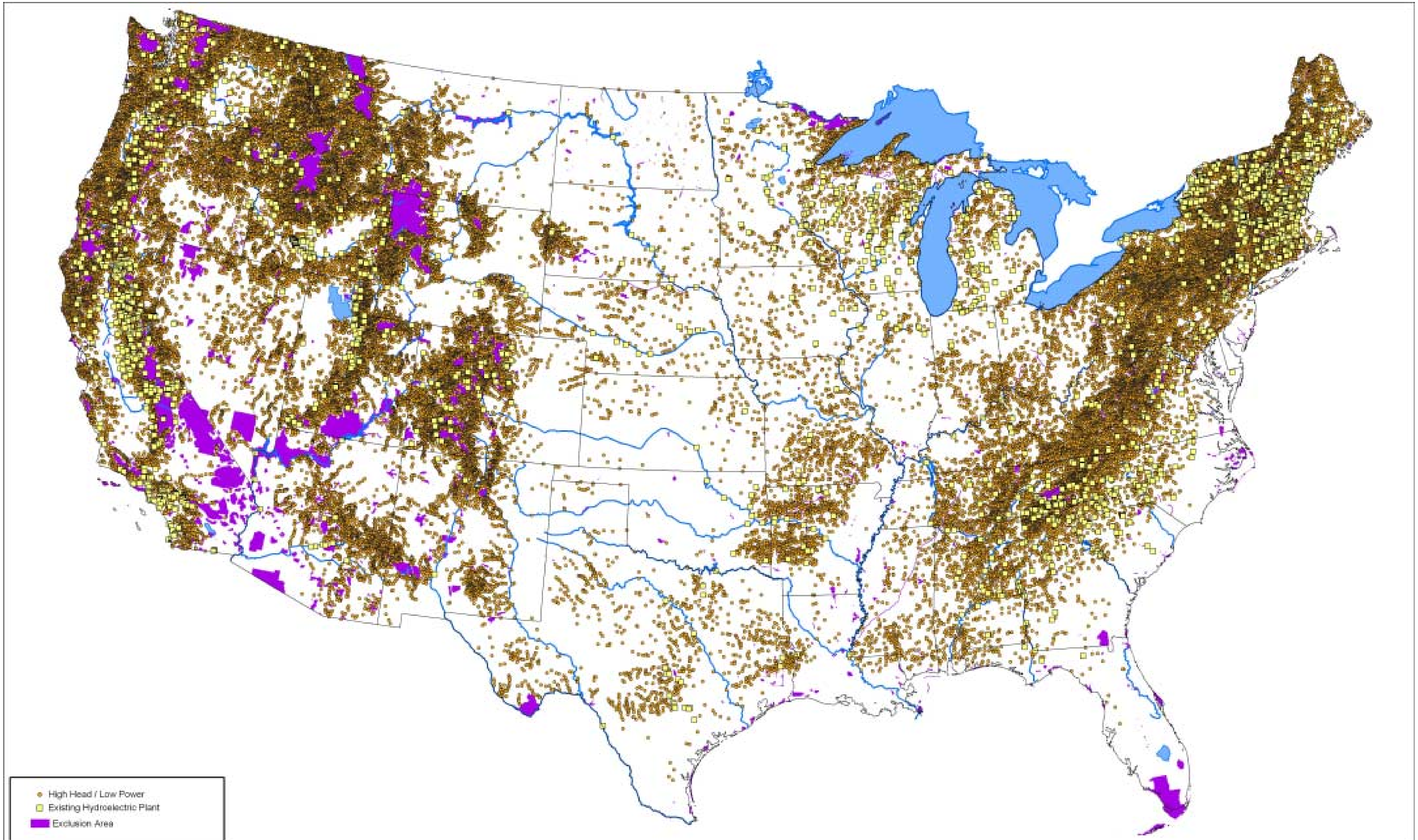

Figure 9. Existing hydroelectric plants and high head/low power hydropower potential sites in the conterminous United States.

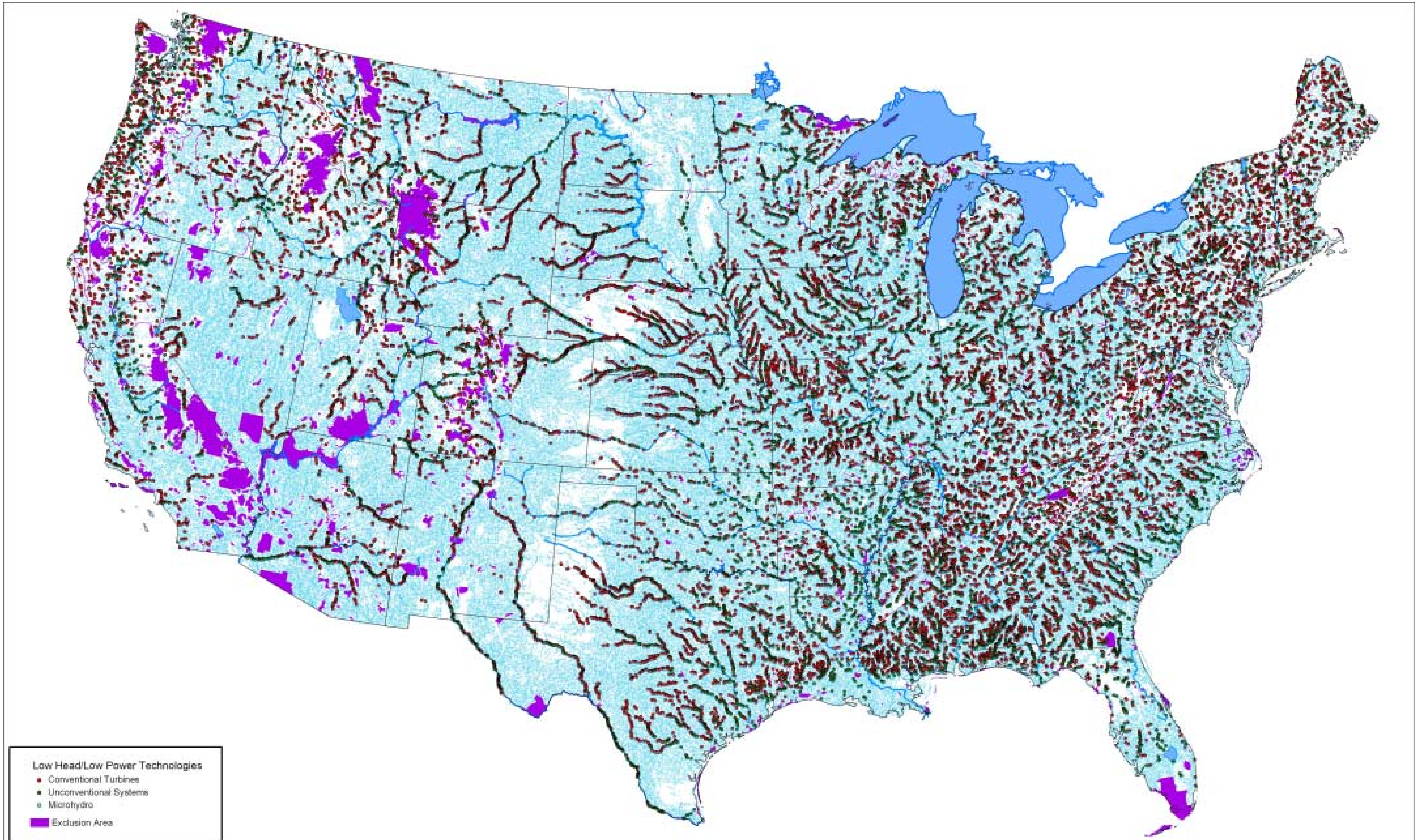

Figure 10. Low/ head/low power hydropower potential sites in the conterminous United States.

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available potential percentages equal to or greater than 80%: Lower Mississippi (92%), Texas Gulf (90%), Ohio (83%), Upper Mississippi (82%), Mid-Atlantic (82%), Great Basin (82%), North Atlantic (81%), and Arkansas-White-Red (80%). The percentage for the conterminous United States as a whole is 60%. The California Region has the largest percentage of excluded potential (45%) with the six next highest regions being in the 20 percentiles.

The relative amounts of hydropower potential are distorted by the relative size of the regions. Therefore, potential values were normalized by dividing them by region planimetric area yielding average hydropower potential densities in units of kW/sq mi. The resulting average total hydropower potential densities subdivided into developed, excluded, and available constituents are compared in Figure 12 by presenting them in ascending order. As expected, the majority of the eight regions with the highest power densities are located east of the Mississippi or on the Pacific coast. These eight regions have average power densities notably higher than the remaining 10 regions, ranging from approximately 70 to 280 kW/sq mi with the Pacific Northwest and California Regions being the highest, respectively. The eight highest ranked regions and their rankings in Figure 12 do not coincide exactly with the eight regions having notably higher total hydropower potentials shown in Figure 11. The average hydropower potential density for the conterminous United States is 69 kW/sq mi corresponding to an average energy potential density of 1,660 kWh/sq mi/day.

Comparison of the average density of developed hydropower represented by the green bar segments in Figure 12 shows that hydropower development has not strictly occurred in correlation with those regions that have the greatest average hydropower potential density. Hydropower development in California has clearly been less than its total potential might indicate because of a large amount of its potential being excluded from development. The Lower Mississippi Region has an extremely low amount of development relative to the potential (1%), which is understandable since a large fraction of this potential lies in the lower Mississippi River and cannot feasibly be realized using conventional technology. Two-thirds of the regions (12 out of 18) have ratios of developed hydropower potential densities to their average total hydropower potential densities less than the average value for all the regions of approximately 20%.

Because available hydropower potential is of the greatest interest, the available hydropower potentials of the 18 hydrologic regions subdivided into high power (≥1 MW), high head/low power (≥30 ft of head and <1 MW), and low head/low power (<30 ft of head and <1 MW) constituents are compared in Figure 13 by presenting them in ascending order of total available hydropower potential. The Pacific Northwest Region contains by far the largest available potential with its nearly 40,000 MW of potential being on the order of four times that of the Lower Mississippi, California, Ohio, and Missouri Regions having available potentials ranging from approximately 9,000 to 11,000 MW. Most of this available power is in the high power class. In the case of the Lower Mississippi Region, probably only a small fraction of this potential could be realized unless unconventional systems are used.

The available hydropower potentials shown in Figure 13 were normalized to produce average available hydropower potential densities. The resulting average available hydropower potential densities subdivided into their three constituents are compared in Figure 14 by presenting them in ascending order. This view reduces the overwhelming plurality of the Pacific Northwest Region and shows three sets of regions based on average available hydropower density. The Pacific Northwest and Lower Mississippi Regions are in the highest range from 110 to 150 kW/sq mi followed by a group of six regions in the range from 50 to 80 kW/sq mi, with the remaining 10 regions being in the 5 to 25 kW/sq mi range.

The average available hydropower potential density for the conterminous United States is 42 kW/sq mi corresponding to an average energy potential density of 1000 kWh/sq mi/day. Six of the eight regions shown to have the highest average total available hydropower potential densities in Figure 14 are the same eight regions shown to have the highest total available potentials in Figure 13.

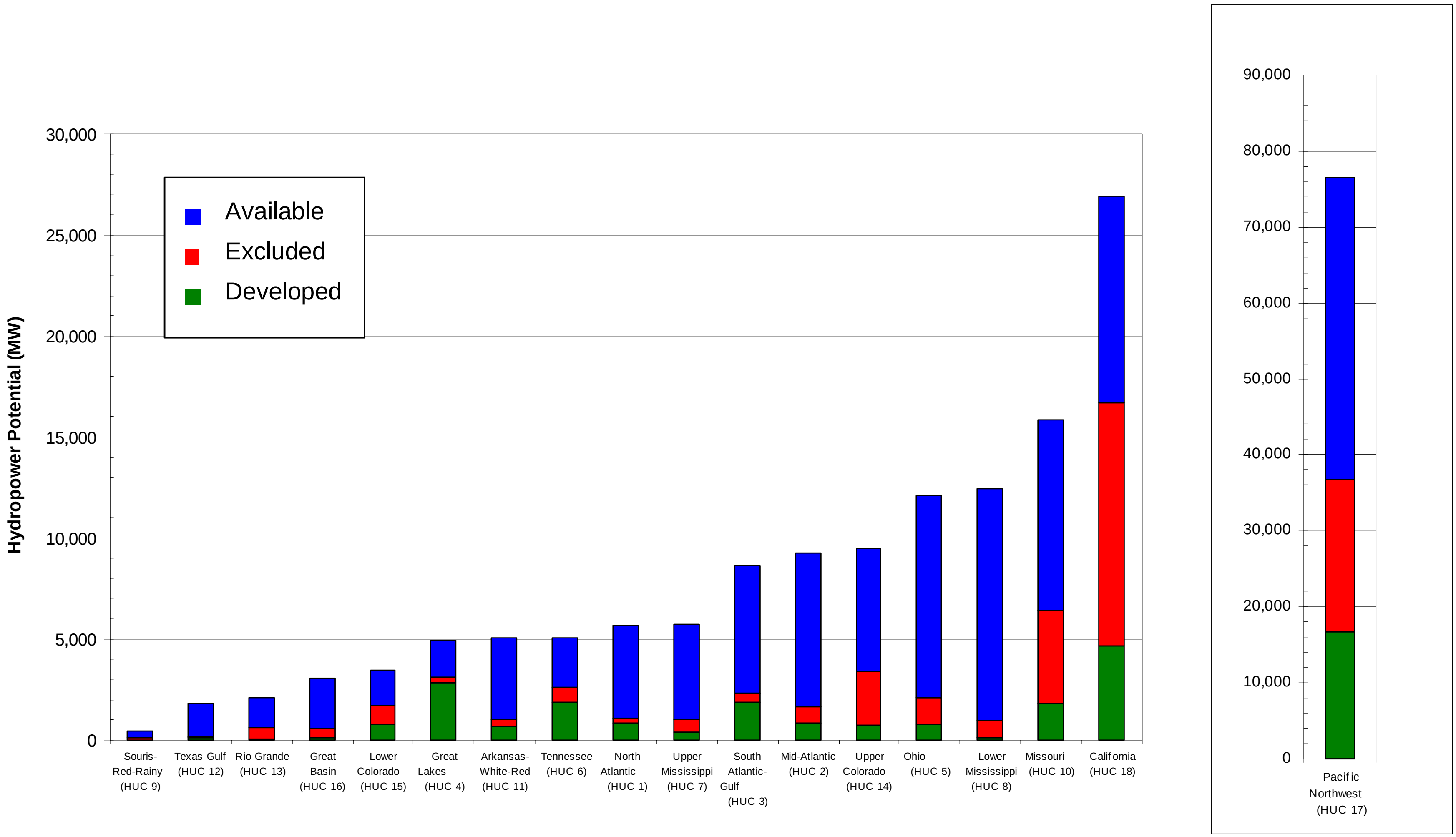

Figure 11. Total hydropower potentials of 18 United States hydrologic regions divided into developed, excluded, and available constituents.

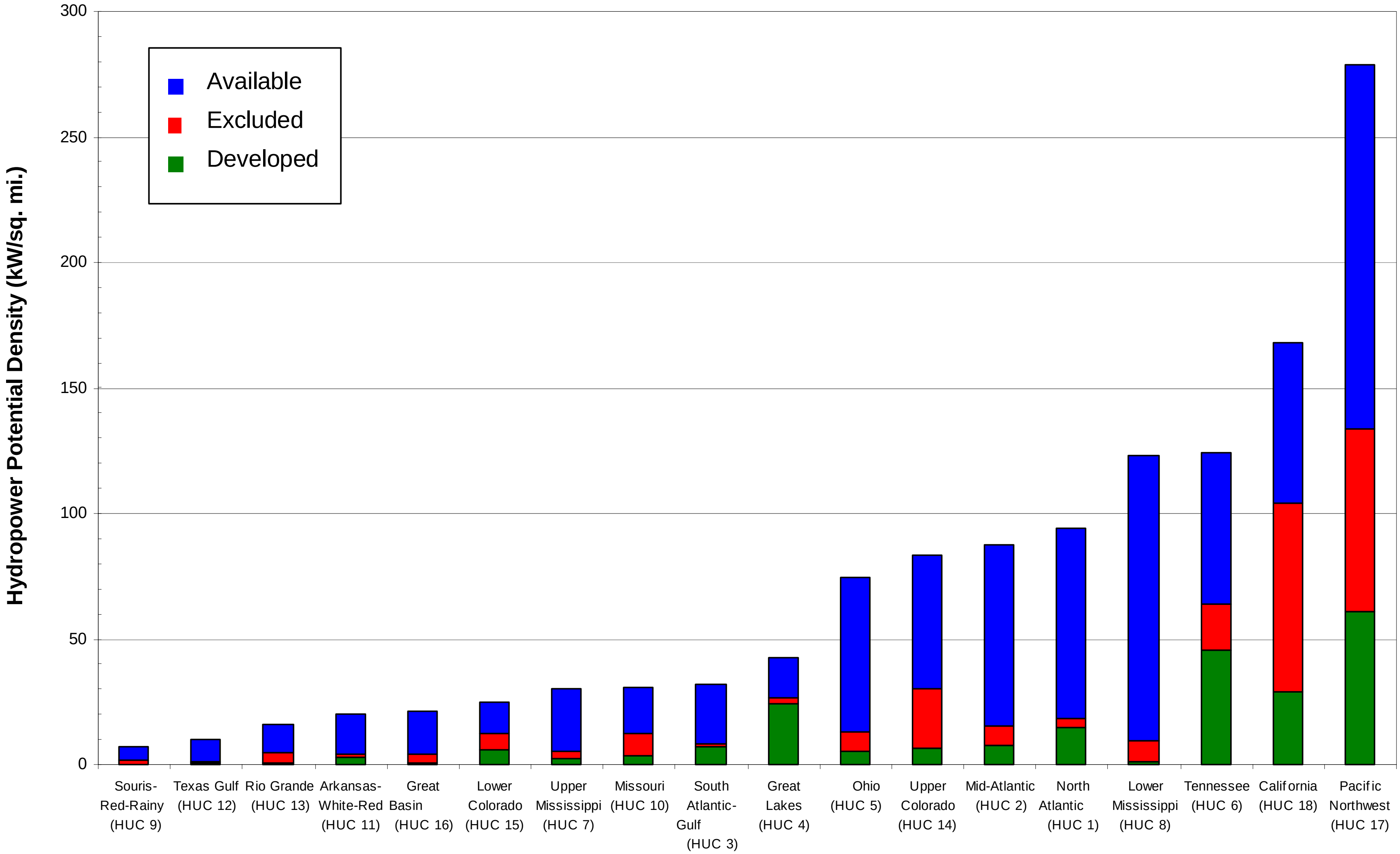

Figure 12. Total hydropower potential densities of 18 United States hydrologic regions divided into developed, excluded, and available constituents.

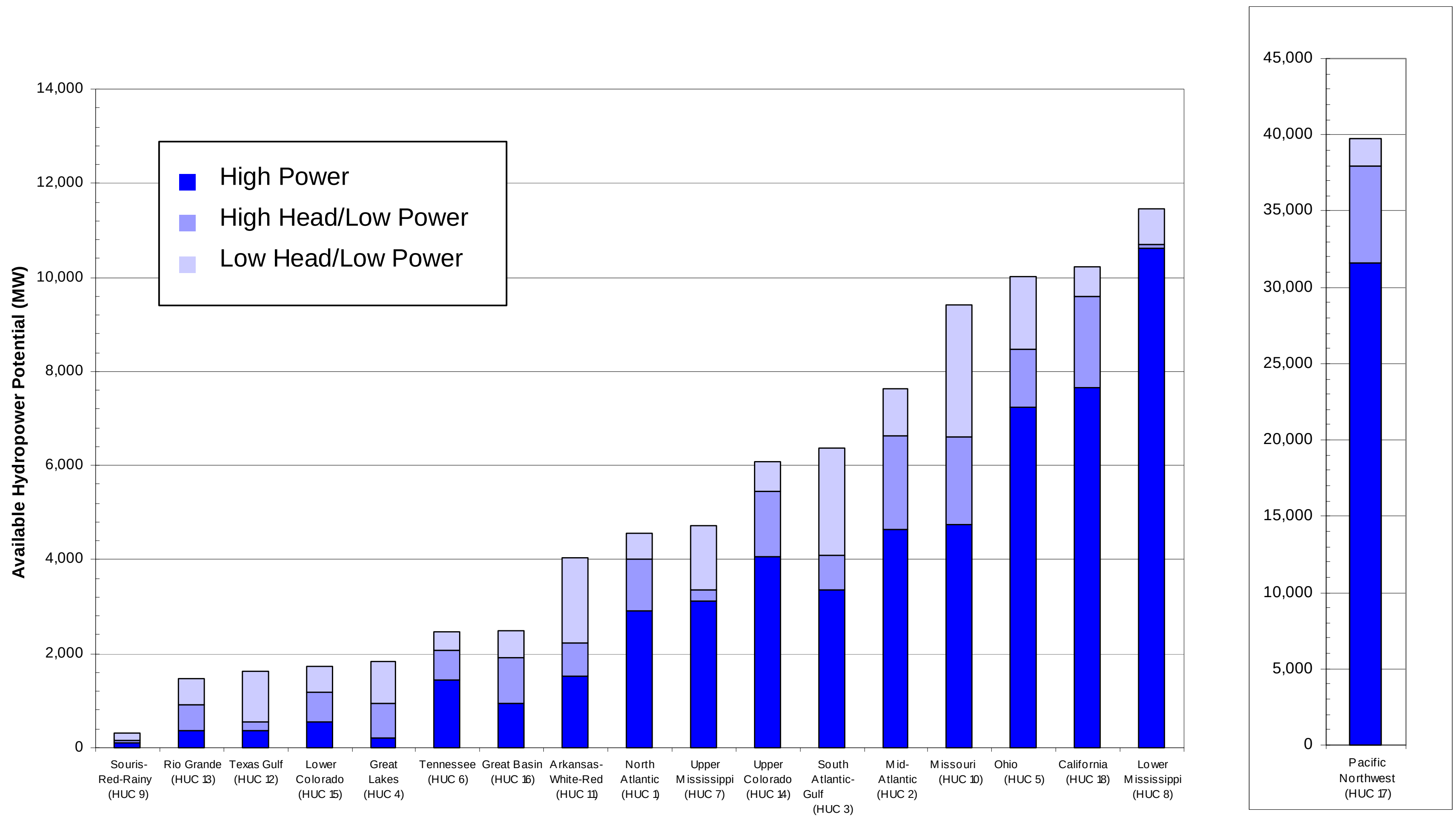

Figure 13. Total available hydropower potentials of 18 United States hydrologic regions divided into high power, high head/low power, and low head/low power constituents.

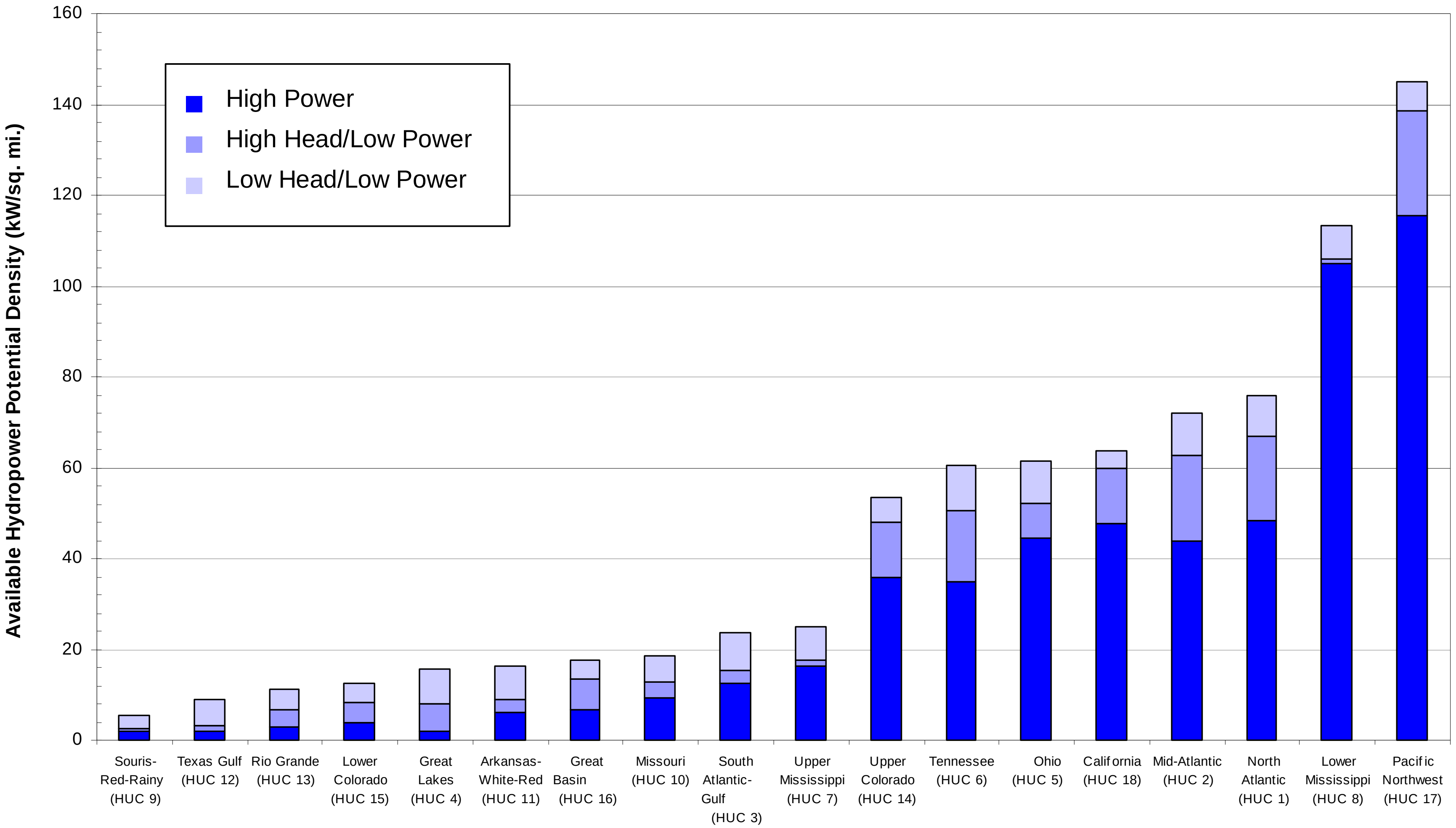

Figure 14. Total available hydropower potential densities of 18 United States hydrologic regions divided into high power, high head/low power, and low head/low power constituents.

However, ranking by average power density is a better indicator of where available potential can be found.

A principal focus of this study was low head/low power hydropower potential. Therefore, the available low head/low power hydropower potentials of the 18 hydrologic regions subdivided into power classes corresponding to the operating envelopes of three classes of low head/low power hydropower technologies are compared in Figure 15 by presenting them in ascending order of available low head/low power hydropower potential. (See Figure 5 for the boundaries of the operating envelopes of the three classes of low head/low power hydropower technologies.) Comparison of the rankings in Figure 15 with those in Figure 13 shows that low head/low power hydropower is generally not proportional to total available hydropower potential. Therefore, it is found in some regions that do not have the largest amounts of total available hydropower. The Missouri Region has the highest low head/low power potential with the Pacific Northwest Region, which has the highest total available potential, being third behind the South Atlantic-Gulf Region. Notably, the Arkansas-White-Red and the Texas Gulf Regions moved up into the upper ranks in this power class. Microhydro constitutes between 42% (Arkansas-White-Red) and 75% (Great Basin) of the available low head/low power potential in the regions. Conventional turbine available potential ranges from 21% (Great Basin) to 40% (Mid-Atlantic and Arkansas-White-Red) of the region’s total available low head/low power potential. The fractions corresponding to unconventional systems are relatively small ranging from 4% (Great Basin) to 29% (Lower Mississippi).

In order to determine the highest concentrations of available low head/low power hydropower potential amongst the regions, the potentials shown in Figure 15 were normalized to produce average available low head/low power hydropower potential densities. The resulting average low head/low power hydropower potential densities subdivided into their three constituents are compared in Figure 16 by presenting them in ascending order. This view gives quite a different picture of where available low head/low power potential is located. Average available low head/low power hydropower densities of about 9 kW/sq mi are indicated for the Tennessee, Ohio, Mid-Atlantic, and North Atlantic Regions. Eleven regions have potential power densities equal to or greater than the country average of 6 kW/sq mi, which corresponds to an average energy potential density of 155 kWh/sq mi/day.

4.5 Comparison of State Hydropower Potentials

The total hydropower potentials of the 48 states in the conterminous United States subdivided into developed, excluded, and available constituents are compared in Figure 17 by presenting them in ascending order of total hydropower potential. Four states have outstandingly higher total hydropower potentials than the other 44 states with their potentials ranging from approximately 18,000 MW to slightly over 30,000 MW. All these states are in the western United States: Washington, which has the highest potential, Idaho, and Oregon are for the most part in the Pacific Northwest Region and California, which comprises the vast majority of the California Region.

These four states have the largest excluded and available potentials of all the states, but the most developed potential lies in the states of Washington, California, Oregon, and New York. Idaho is not among the top four states for developed potential because despite its large total hydropower potential, only 7% has been developed.

On a percentage of total hydropower potential basis, Washington is the only one of the states with the highest amount of potential that ranks in the top five states that have the largest percentages of developed power. These states are: North Dakota (93%), South Dakota (72%), New York (58%), Washington (37%), and Alabama (35%). Two states have excluded potentials that exceed 40% of the state total hydropower potential, Wyoming (46%) and California (44%). Six states have excluded potential percentages in the 30 percentiles. From the perspective of available potential percentages, 22 states have available potential percentages equal to or greater than 80%. A total of 37 states have available potential percentages greater than or equal to the national percentage of 60%.

The relative amounts of hydropower potential shown in Figure 17 are distorted by the relative size of the states. Therefore, the potential values were normalized by dividing them by the planimetric area of the state yielding average hydropower potential densities in units of kW/sq mi. The resulting average total hydropower potential densities subdivided into developed, excluded, and available constituents are compared in Figure 18 by presenting them in ascending order. From this perspective, the four states having the largest total hydropower potentials also have the highest total hydropower potential densities ranging from approximately 170 to 460 kW/sq mi. The superiority of Washington state in total hydropower potential is accentuated when viewed from this perspective, being approximately twice as high as that of Idaho, the next closest state. The 17 states with the highest power densities are located east of the Mississippi or on the Pacific coast. Comparison of the average density of developed hydropower represented by the green bar segments in Figure 18 shows that hydropower development has generally not occurred in correlation with those states having the greatest average hydropower density.

The available hydropower potentials of the states subdivided into high power, high head/low power, and low head/low power constituents are compared in Figure 19. The states are presented in ascending order of total available hydropower potential. The four states having the largest total hydropower potentials also have the highest available hydropower potentials ranging from approximately 9,000 to slightly over 12,000 MW. In general, high power potential is the largest constituent of the available power potentials.

The available hydropower potentials shown in Figure 19 were normalized to produce average available hydropower potential densities. The resulting average available hydropower potential densities subdivided into their three constituents are compared in Figure 20 by presenting them in ascending order. The ranking by average power density is a better indicator of where available hydropower potential can be found. The states shown to have the higher average total available hydropower densities in Figure 20 are not in all cases the same states shown to have the highest total available potentials in Figure 19. From this perspective, Washington (184 kW/sq mi) and Idaho (143 kW/sq mi) have outstanding power densities compared to the other states. Following these two states, there is a group of 14 states having power densities in the range of 60 to 110 kW/sq mi all of which are east of the Mississippi River with the exception of California and Oregon.

The available low head/low power hydropower potentials of the 48 states subdivided into power classes corresponding to the operating envelopes of three classes of low head/low power hydropower technologies are compared in Figure 21. The states are presented in ascending order of available low head/low power hydropower potential. This figure shows that because available low head/low power hydropower is generally not proportional to total available hydropower potential (compare with Figure 19), Oregon is the only state having outstanding amounts of total available potential that ranks in the top four having the largest amounts of available low head/low power potential. Texas has the highest low head/low power potential with Washington, which had the highest total available potential being a distant 26 in the ranking. Microhydro constitutes between 34% (Oklahoma) and 82% (Nevada) of the available low head/low power potential in the states. Conventional turbine available potential ranges from 14% (Delaware) to 51% (Nebraska) of the state total available low head/low power potential. The fractions corresponding to unconventional systems are relatively small ranging from 2% (Nevada) to 33% (Florida).

The superiority of Texas in possessing available low head/low power potential is seen to be largely the result of the size of the state when this potential is viewed from a power density perspective as shown in Figure 22. This view gives quite a different picture of where available low head/low power potential is located. From this perspective, Texas is ranked 35th. Alabama has the highest power density (12 kW/sq mi) with a group of the highest 21 states having power densities in the range of approximately 8 to 12 kW/sq mi. Notably, all these states are in the eastern half of the United States; the vast majority being east of the Mississippi River.

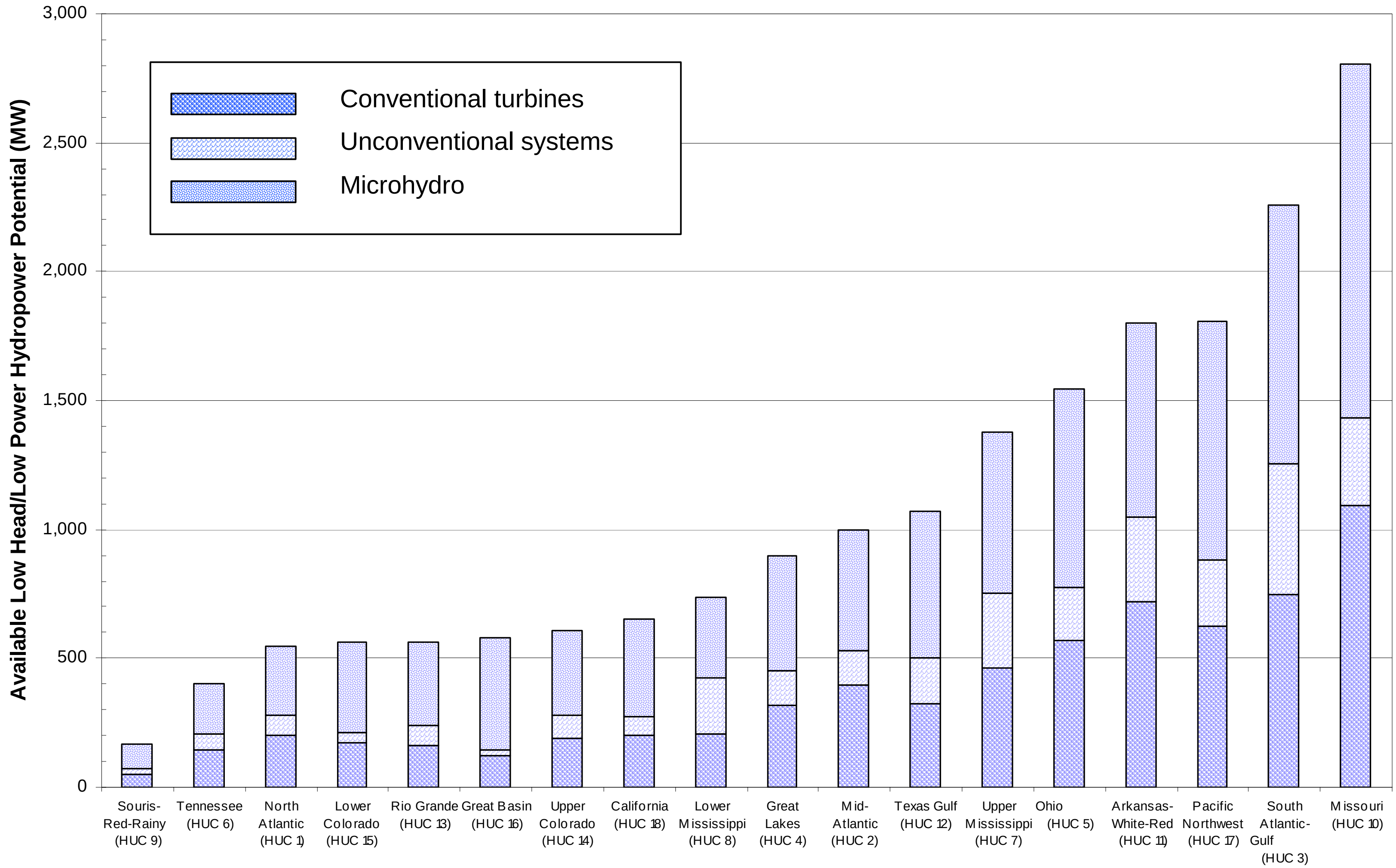

Figure 15. Available low head/low power hydropower potentials of 18 United States hydrologic regions divided into conventional turbines, unconventional systems, and microhydro constituents.

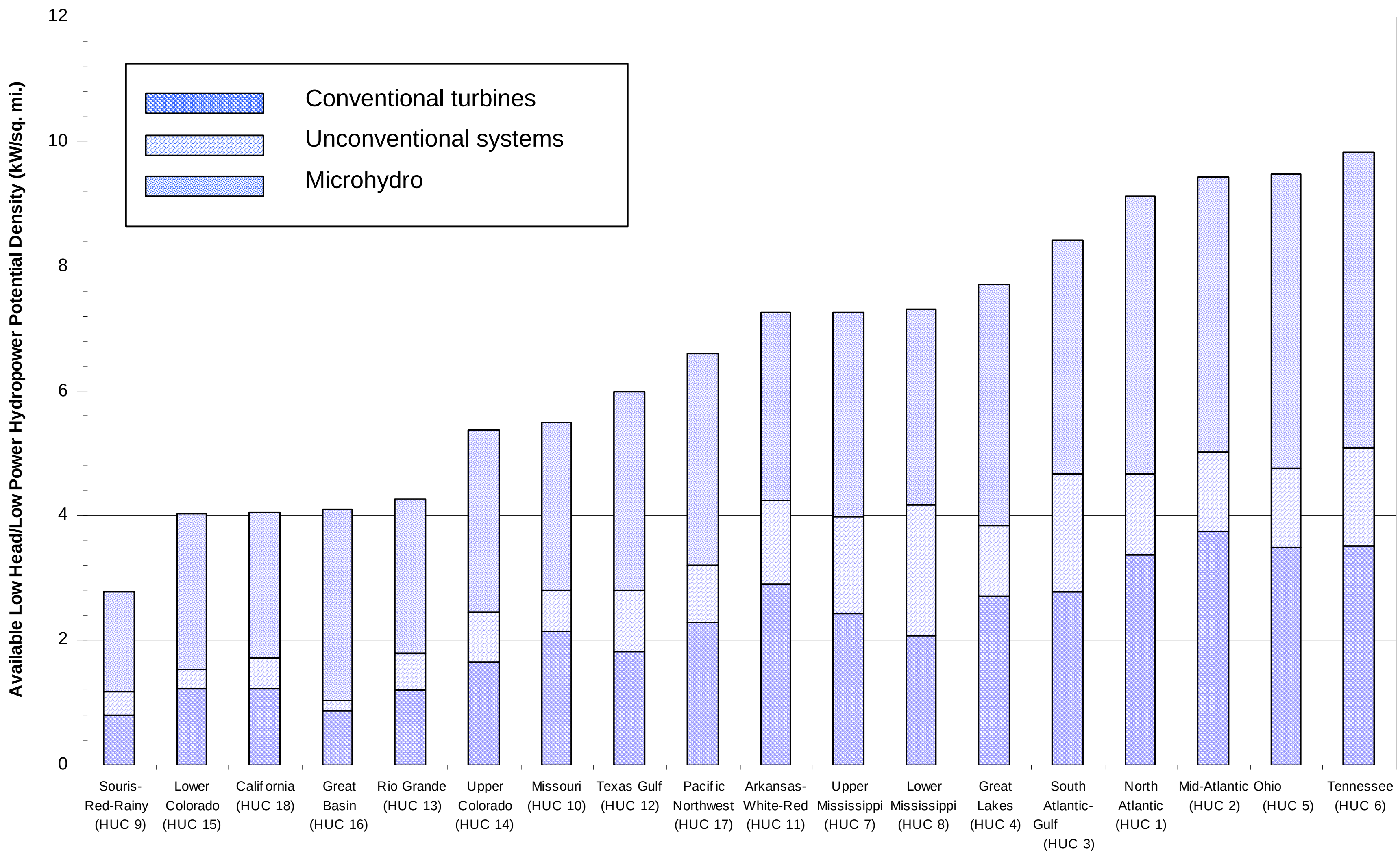

Figure 16. Available low head/low power hydropower potential densities of 18 United States hydrologic regions divided into conventional turbines, unconventional systems, and microhydro constituents.

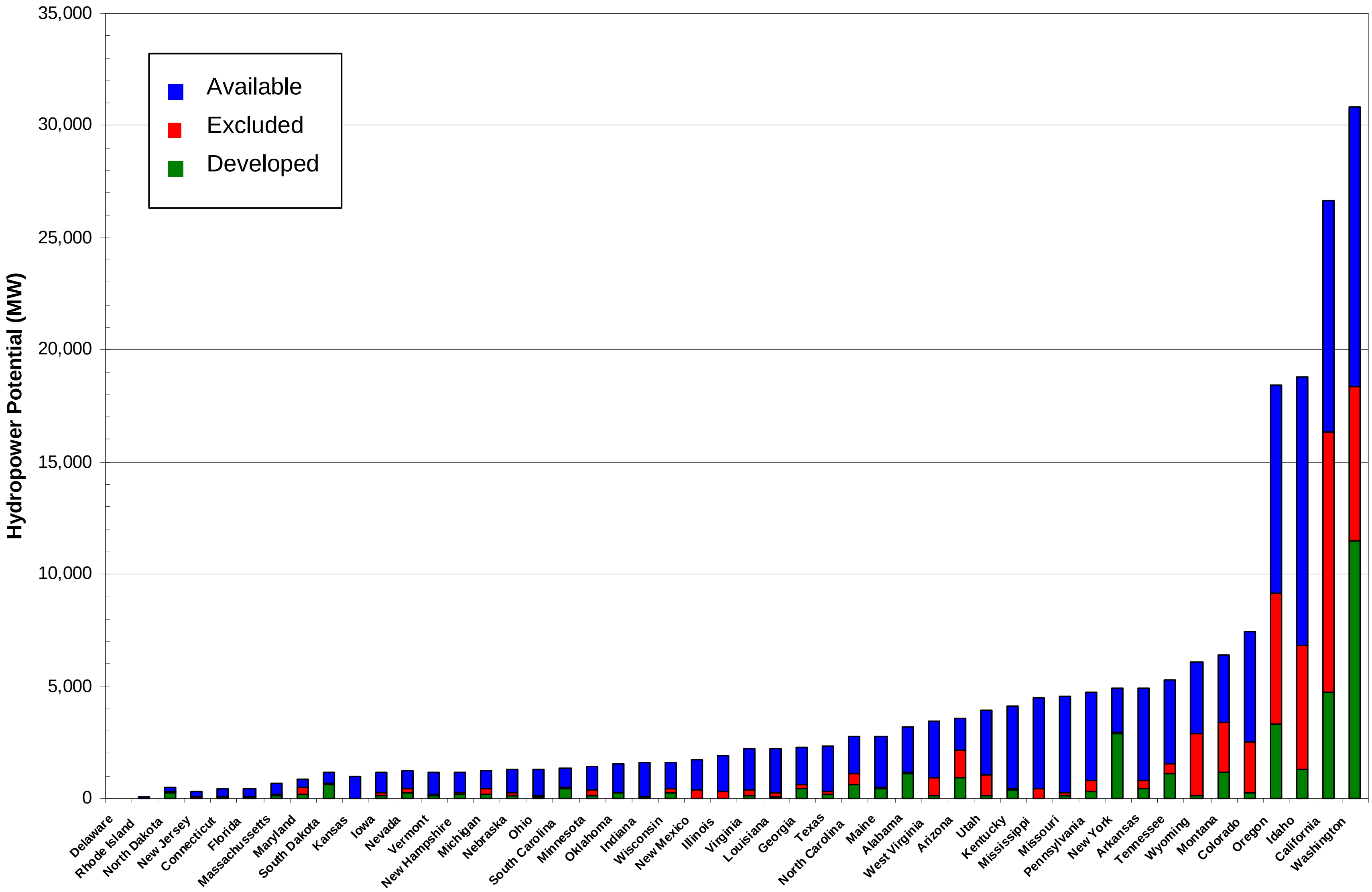

Figure 17. Total hydropower potential of the 48 states of the conterminous United States divided into developed, excluded, and available constituents.

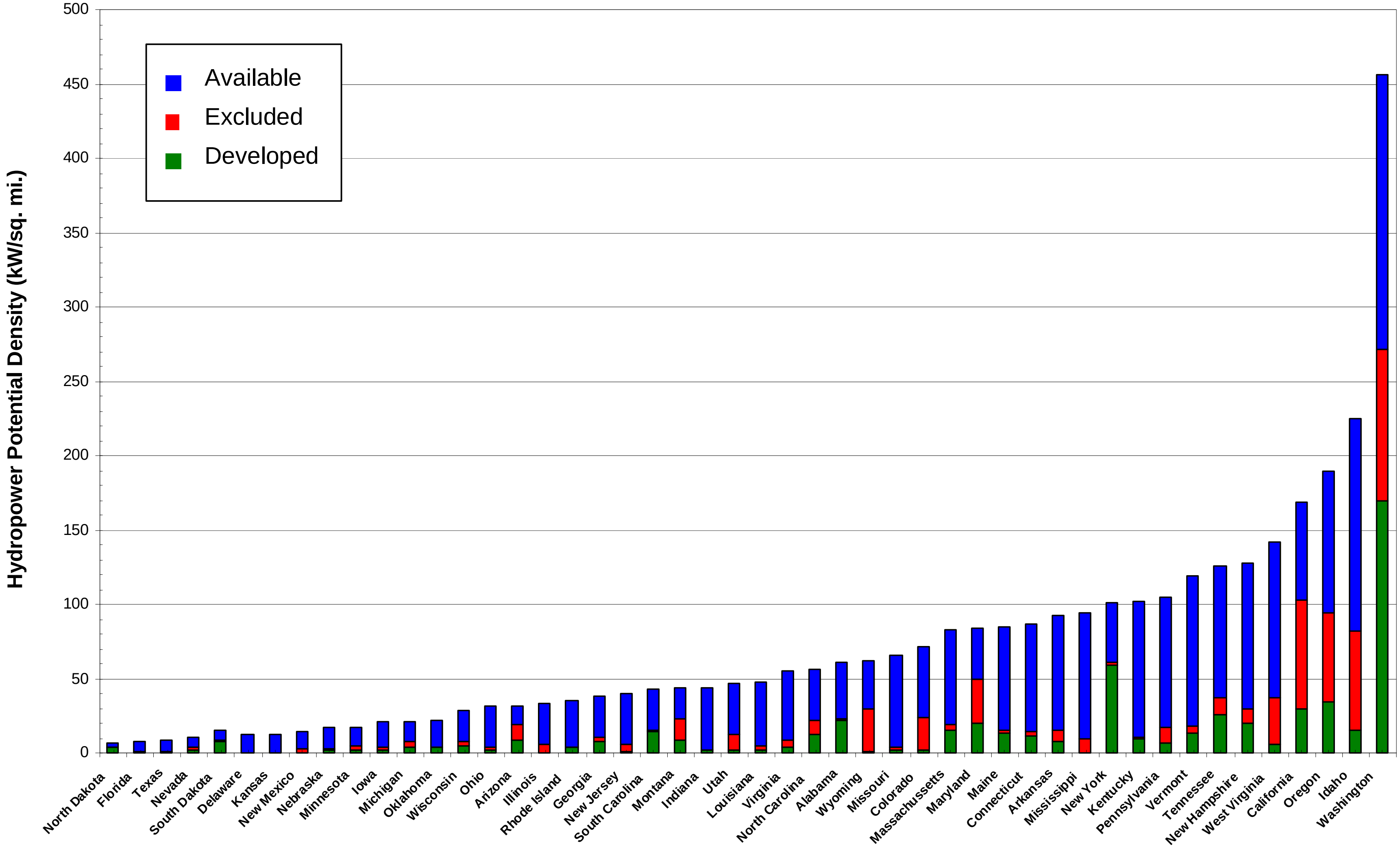

Figure 18. Total hydropower potential densities of the 48 states of the conterminous United States divided into developed, excluded, and available constituents.

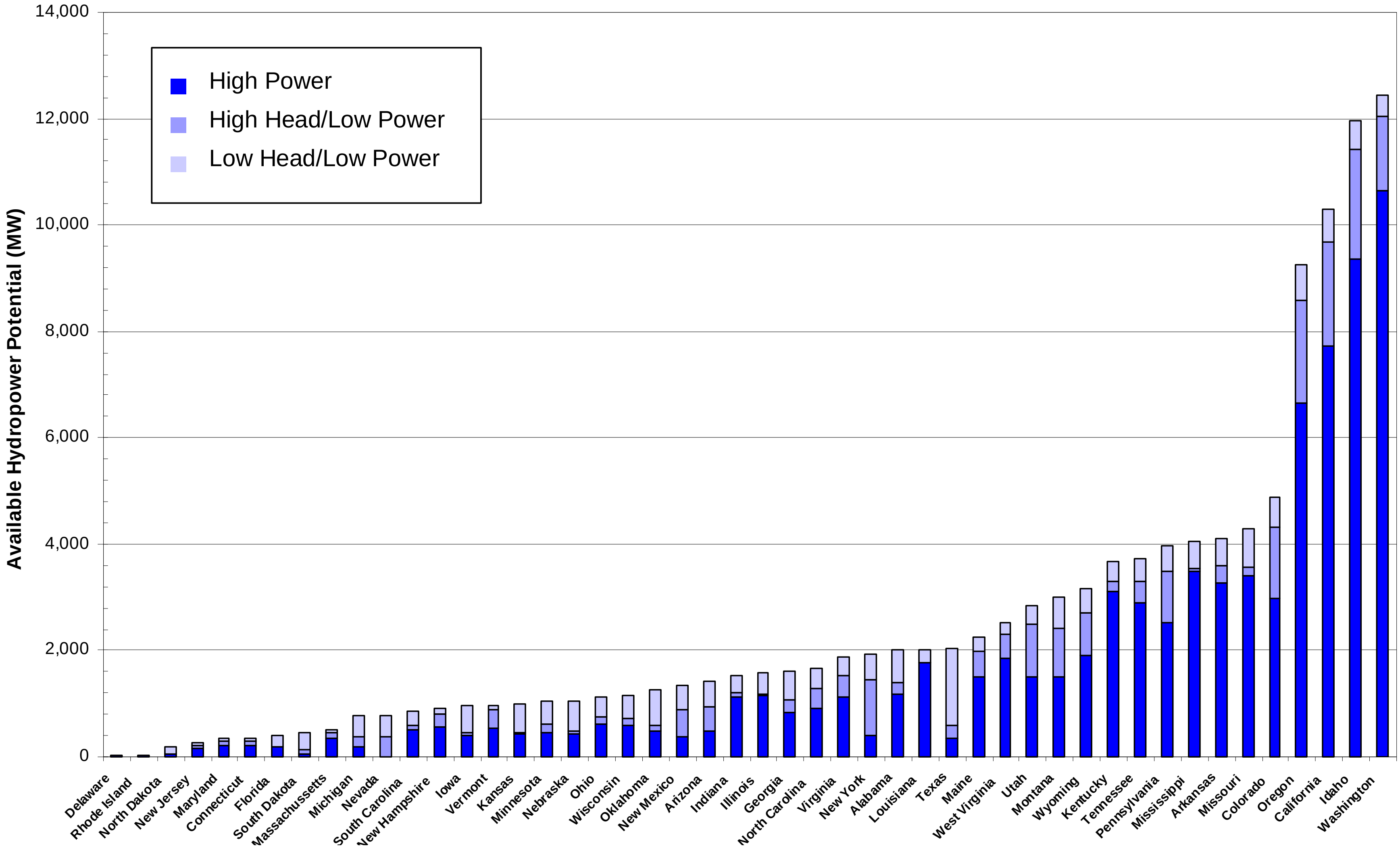

Figure 19. Total available hydropower potentials of the 48 states of the conterminous United States divided into high power, high head/low power, and low head/low power constituents.

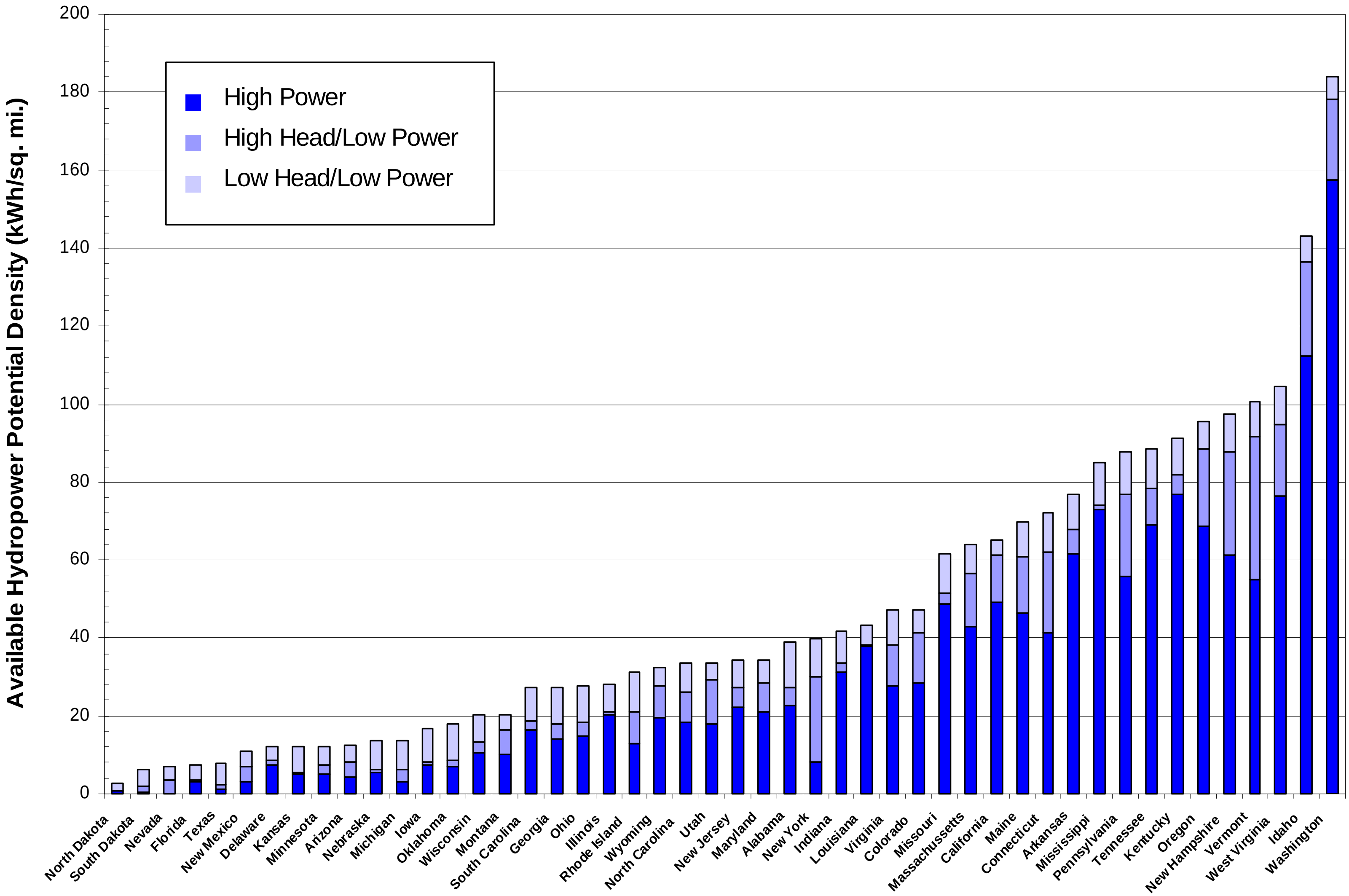

Figure 20. Total available hydropower potential densities of the 48 states of the conterminous United States divided into high power, high head/low power, and low head/low power constituents.

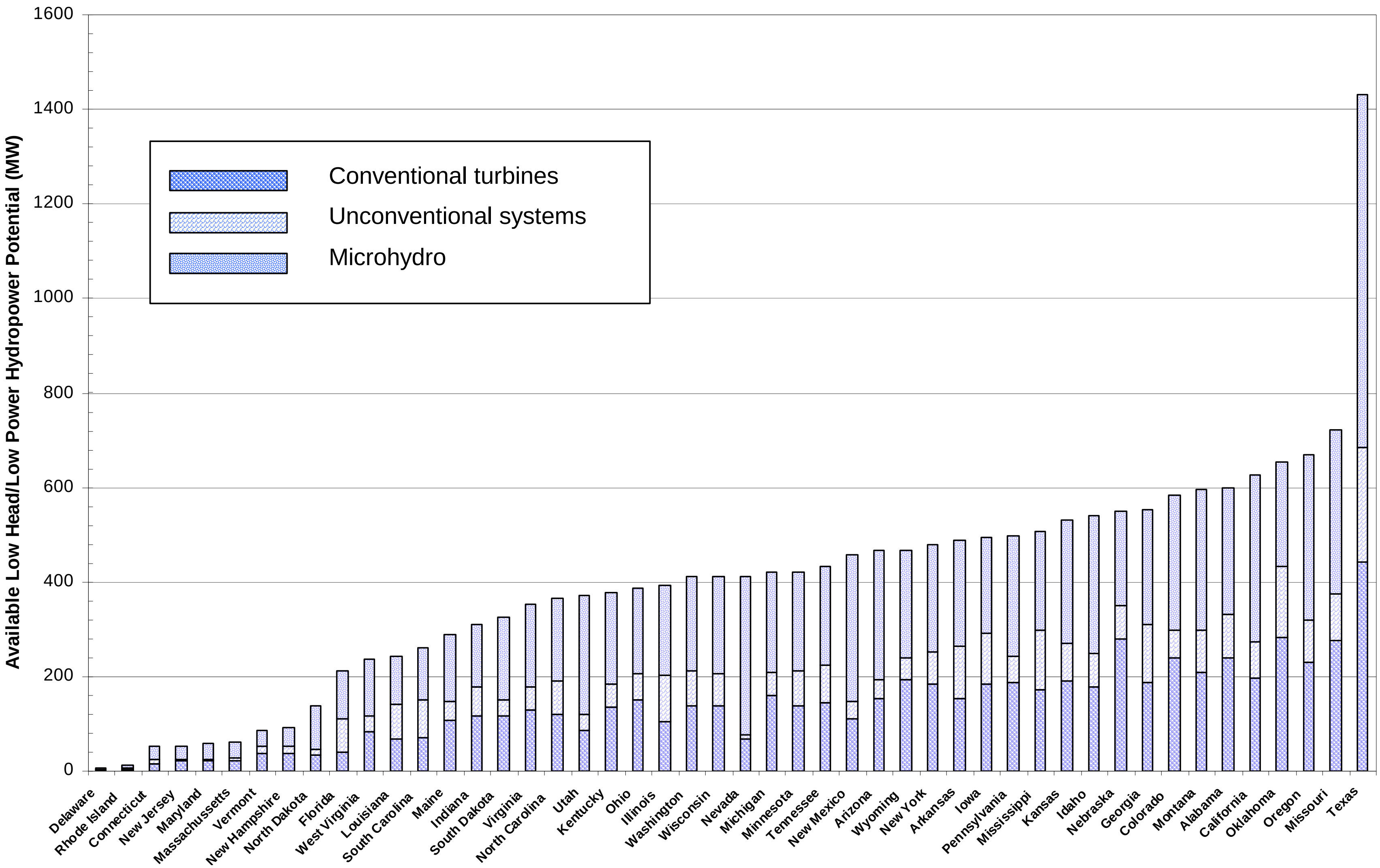

Figure 21. Available low head/low power hydropower potentials of the 48 states of the conterminous United States divided into conventional turbines, unconventional systems, and microhydro constituents.

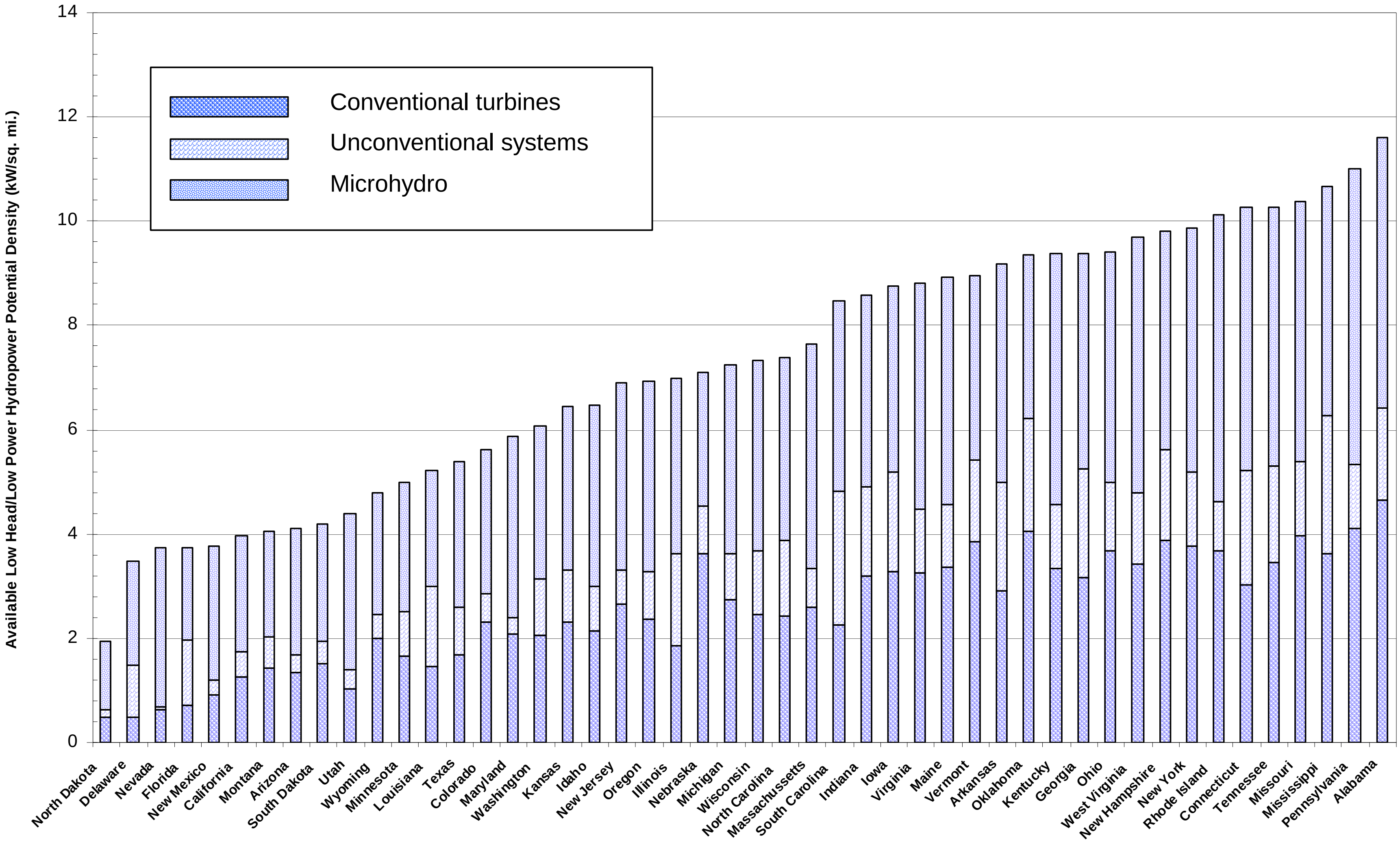

Figure 22. Available low head/low power hydropower potential densities of the 48 states of the conterminous United States divided into conventional turbines, unconventional systems, and microhydro constituents.

5. CONCLUSIONS AND RECOMMENDATIONS

This study has demonstrated that it is possible to estimate the hydropower potential of the conterminous United States based on the potentials of mathematical analogs of every stream segment in the country. Furthermore, stream segment potentials can be aggregated to determine the hydropower potential in various power classes within geographic areas of interest and to locate the potential at discrete geographic coordinates.

The study has resulted in an estimate of the hydropower potential of the conterminous United States of approximately 200,000 MW corresponding to an annual energy production of 1,752,000 GWh. Of this potential, about 35,000 MW corresponding to the approximately 75,000 MW capacity of existing hydroelectric plants has been developed. Hydropower potential in zones that exclude new hydropower development accounts for about 46,000 MW. This leaves approximately 120,000 MW of potential or 60% of the total that has not been developed and is not excluded from development. This potential power corresponds to an annual energy production of 1,051,200 GWh. Ninety percent (90%) of this available potential is composed of high power potential (≥1 MW), high head/low power (head ≥30 ft and <1 MW) potential and part of the low head/low power (head <30 ft and <1 MW) potential that could be realized using conventional turbine technology, but perhaps in new configurations not requiring impoundments determined by future research and development.

The estimated, available, low head/low power potential of approximately 19,000 MW constitutes 16% of the total available potential. High head/low power potential adds another 20,000 MW (17% of the total); therefore, low power potential is one-third of the total available hydropower potential. Thirty-five percent (35%) of the low head/low power potential and all the high head/low power could be realized using conventional turbines, but perhaps in new system configurations. However, nearly two-thirds (65%) of the low head/low power potential corresponds to technologies (microhydro and unconventional systems) that would require additional turbine and system configuration research and development; although, some units currently exist that could be put into service.

The study has shown that half of the hydropower potential of the country resides in the top two hydrologic regions: Pacific Northwest (37%) and California (13%); in particular, in the states of Washington, California, Idaho, and Oregon. Half of the available hydropower potential resides in the top three regions: Pacific Northwest (32%), Lower Mississippi (9%), and California (8%). Viewed from the perspective of where the greatest concentrations of available hydropower potential are located, Washington and Idaho have the highest concentrations with Oregon and California and 12 states east of the Mississippi making up the balance of the states in which available potential is most densely concentrated.

Because low head/low power potential is not directly proportional to the total hydropower potential, the rankings of the states with the maximum amount and concentrations of available low head/low power potential, are not the same as for total available power. For this power class, regions and states having the most potential are scattered around the country. However, from the perspective of where the highest concentrations of low head/low power potential are located, the eastern United States is the clear sector of the country having the highest concentrations with five hydrologic regions and 21 states, most of them east of the Mississippi at the top of the rankings.

The average percentage of developed potential for the country is approximately 20%. In light of the fact that 12 of the 18 hydrologic regions and 33 of the 48 states have developed power percentages less than the national average, it is clear that most of the regions and states are underdeveloped with respect to hydroelectric power. This conclusion is further supported by the fact that 21 states have 80% or more of their total hydropower potential available for development, and 39 states have more available than the national average (60%) of available hydropower potential.

The estimates of available hydropower potential produced by this study are sufficiently large to warrant further research regarding possible siting of additional hydroelectric plants. Low power sites are sufficiently numerous and uniformly distributed over the country to offer significant sources of distributed power without the need for reservoirs.

With the resource assessment of the conterminous United States completed, we plan to assess the hydropower potential of the States/hydrologic regions of Alaska and Hawaii using the same technical approach. This will require extension of the EDNA database to these states. The basic data for this extension, the required climatic data, and equations for estimating stream flow rate all exist. Therefore, this research is currently underway and will be included in the final version of this draft report.

While the estimates of available hydropower potential are significantly large to warrant additional research, it is probably not feasible to develop a significant fraction of this potential. In order to obtain a clearer estimate of the amount of hydropower potential that can feasibly be developed and determine which sites are feasible, it is necessary to intersect the locations of potential with context parameters that govern its feasibility of development. These parameters include proximity to population centers, industry, and existing infrastructure (e.g., roads, railroads, and electric transmission lines) and locations inside or outside of nonfederal mandated exclusion areas. Because all the data generated in this project are geo-referenced and the necessary GIS tools and most of the needed context layers exist, we recommend that this research be conducted.

The hydropower potential estimates provided in this report have large uncertainties for some hydrologic regions, because of the uncertainty in the flow rate estimation equations used to produce them. Use of flow rate prediction equations developed for smaller areas than entire hydrologic regions would probably offer increased flow rate prediction accuracy and thus increased hydropower potential accuracy. Research should be conducted to locate such equations, and the study results should be upgraded using these more accurate equations.

Although a small validation study was performed, we recommend that results of stream reach flow rate and hydropower potential calculations be benchmarked against a significant number of locations around the country with known, gauged flow rates and associated hydraulic heads. This validation study should be driven by the availability of EDNA synthetic hydrography that has been validated by the U.S. Geological Survey in its ongoing efforts to obtain correlation between EDNA hydrography and that provided by the more accurate NHD.

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Appendix A

Assessment Results by Hydrologic Region

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Assessment Results by Hydrologic Region

This appendix contains results of the hydropower assessments of the 18 hydrologic regions of the conterminous United States. The regional results are presented in Table A-0 to facilitate lookup of hydropower potential values and comparison of these values amongst the regions.[a] This summary information is followed by 18 sections, each devoted to a particular region. Each section has the same format, which includes a description of the geographic features of the region and a table listing hydropower potential values by power class and category (total, developed, excluded, and available). The data in the table are presented in a series of pie charts to graphically illustrate the distribution of category and classes of hydropower potential amongst their constituent parts. The section concludes with maps showing the locations of existing hydroelectric plants and low power potential sites in the region.

The results presented in this appendix do not include any assessment of the feasibility of developing or the actual availability for development of any hydropower resources. The term “available” used in the tables and figures in this appendix only denotes the net amount of hydropower potential after subtracting the amounts of developed and excluded hydropower potential from the gross amount of hydropower potential.

A.1 North Atlantic Hydrologic Region

A.1.1 Region Description

The topographic and hydrographic features of the North Atlantic Region are shown in Figure A-1. The North Atlantic Region covers most or all of the following New England states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. The New England Upland, a northern extension of the Appalachian Mountains, occupies the inland portion of the North Atlantic Region. The New England Upland consists of wooded mountains, many of which reach several thousand feet in elevation. The remainder of the region, the Seaboard Lowland, is a series of coastal plains and rolling low hills between the mountains and the sea. In Maine, rolling hills directly border the Atlantic Ocean, forming a rugged, irregular shoreline of alternating bays, peninsulas, and islands.

The Connecticut River is the only major river in the New England Region. It flows southward, forming the boundary between New Hampshire and Vermont before crossing Massachusetts and Connecticut where it discharges into Long Island Sound.

The climate is humid continental: warm summers and cold winters are found in the south, while cool summers and severe winters dominate the northern interior. Coastal regions are subject to marine influence, including severe winter storms from the North Atlantic Ocean (nor’easters) and the possibility of tropical storms or hurricanes in the summer.

A.1.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power

a. The United States and some regional total, excluded, and available potentials in this table are 4–5% higher than the more accurate values listed in a corresponding table in Appendix B because of the more discriminating state boundaries GIS layer used compared to that for the region boundaries. These inaccuracies should have little effect on the percentage values listed in the lower part of the table. The sum of the state hydropower potentials in the various categories and power classes have been used as the official estimates for the conterminous United States.

fractions of the total available hydropower potential

- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes.

- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

Table A-0. Summary of regional hydropower potentials and percentages of totals by category and power class.

		Total Potential				Available Potential			Available Low Head/Low Power Potential		
HUC #	Name	Total (MW)	Developed (MW)	Excluded (MW)	Available (MW)	High Power (MW)	High Head/ Low Power (MW)	Low Head/ Low Power (MW)	Conventional Turbines (MW)	Unconventional Systems (MW)	Microhydro (MW)
1	North Atlantic	**5,659**	873	222	4,564	2,901	1,114	549	203	78	268
2	Mid-Atlantic	**9,255**	840	798	7,617	4,649	1,972	996	397	133	466
3	South Atlantic-Gulf	**8,661**	1,849	453	6,359	3,353	746	2,260	748	507	1,005
4	Great Lakes	**4,352**	2,852	271	1,841	208	733	900	317	132	451
5	Ohio	**12,109**	820	1,275	10,014	7,249	1,220	1,545	567	208	770
6	Tennessee	**5,076**	1,859	743	2,474	1,432	640	402	144	64	194
7	Upper Mississippi	**5,765**	404	630	4,731	3,126	227	1,378	462	293	623
8	Lower Mississippi	**12,418**	136	835	11,447	10,612	97	738	209	213	316
9	Souris Red-Rainy	**431**	13	101	317	107	45	165	48	22	95
10	Missouri	**15,824**	1,797	4,622	9,405	4,748	1,850	2,807	1,091	340	1,376
11	Arkansas-White-Red	**5,053**	696	329	4,028	1,533	696	1,799	721	329	749
12	Texas Gulf	**1,811**	127	61	1,623	357	194	1,072	325	179	568
13	Rio Grande	**2,122**	50	602	1,470	376	530	564	159	78	327
14	Upper Colorado	**9,489**	724	2,692	6,073	4,059	1,404	610	188	89	333
15	Lower Colorado	**3,453**	790	931	1,732	560	609	563	171	42	350
16	Great Basin	**3,043**	98	452	2,493	933	980	580	123	24	433
17	Pacific Northwest	**76,439**	16,676	20,009	39,754	31,634	6,312	1,808	627	254	927
18	California	**26,952**	4,674	12,043	10,235	7,648	1,935	652	198	77	377
	U.S. Total	**207,913**	**35,279**	**47,069**	**126,177**	**85,485**	**21,304**	**19,388**	**6,698**	**3,062**	**9,628**

HUC #	Name	Total[a]	Developed[b]	Excluded[b]	Available[b]	High Power[c]	High Head/ Low Power[c]	Low Head/ Low Power[c]	Conventional Turbines[d]	Unconventional Systems[d]	Microhydro[d]
1	North Atlantic	**3%**	15%	4%	**81%**	64%	**24%**	12%	**37%**	14%	49%
2	Mid-Atlantic	**4%**	9%	9%	**82%**	61%	**26%**	13%	**40%**	13%	47%
3	South Atlantic-Gulf	**4%**	**21%**	5%	**73%**	53%	12%	**36%**	33%	22%	44%
4	Great Lakes	**2%**	**66%**	6%	42%	11%	**40%**	**49%**	**35%**	**15%**	**50%**
5	Ohio	**6%**	7%	11%	**83%**	**72%**	12%	**15%**	**37%**	13%	**50%**
6	Tennessee	**2%**	**37%**	15%	49%	58%	**26%**	**16%**	**36%**	**16%**	48%
7	Upper Mississippi	**3%**	7%	11%	**82%**	66%	5%	**29%**	34%	**21%**	45%
8	Lower Mississippi	**6%**	1%	7%	**92%**	**93%**	1%	6%	28%	**29%**	43%
9	Souris Red-Rainy	**0%**	3%	**23%**	**74%**	34%	14%	**52%**	29%	13%	**58%**
10	Missouri	**8%**	11%	**29%**	59%	50%	**20%**	**30%**	**39%**	12%	49%
11	Arkansas-White-Red	**2%**	14%	7%	**80%**	38%	**17%**	**45%**	**40%**	**18%**	42%
12	Texas Gulf	**1%**	7%	3%	**90%**	22%	12%	**66%**	30%	17%	**53%**
13	Rio Grande	**1%**	2%	**28%**	**69%**	26%	**36%**	**38%**	28%	14%	**58%**
14	Upper Colorado	**5%**	8%	**28%**	**64%**	67%	**23%**	10%	31%	15%	**55%**
15	Lower Colorado	**2%**	**23%**	**27%**	50%	32%	**35%**	**33%**	30%	7%	**62%**
16	Great Basin	**1%**	3%	15%	**82%**	37%	**39%**	**23%**	21%	4%	**75%**
17	Pacific Northwest	**37%**	**22%**	**26%**	52%	**80%**	16%	5%	**35%**	14%	**51%**
18	California	**13%**	**17%**	**45%**	38%	**75%**	**19%**	6%	30%	12%	**58%**
	U.S. Average		**17%**	**23%**	**61%**	**68%**	**17%**	**15%**	**35%**	**16%**	**50%**

a. Regional percentage of total United States hydropower potential
b. Percentage of regional total hydropower potential
c. Percentage of regional total available hydropower potential
d. Percentage of regional total low head/low power hydropower potential

Note 1: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.
Note 2: The United States and some regional total, excluded, and available potentials listed are 4-5% higher than in the corresponding table in Appendix B, which contains more accurate United States values.
Note 3: Bolded figures indicate values greater than or equal to the United States average.
Note 4: Blue background indicates constituent with the largest percentage.
Note 5: Numbers in yellow font indicate that sums by potential category and power class do not match; see regional summary for explanation.

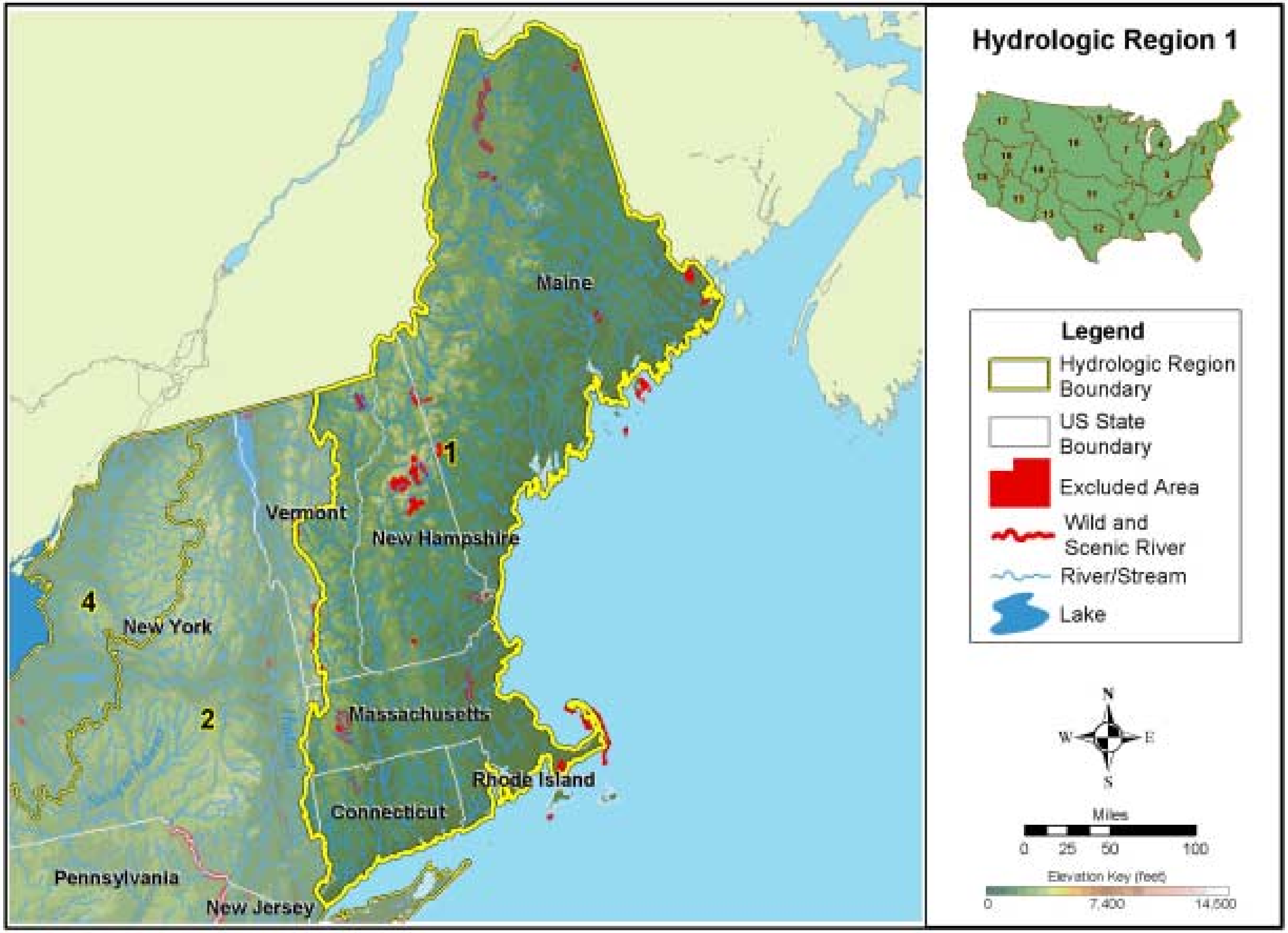

Figure A-1. North Atlantic Hydrologic Region (HUC 1).

Table A-1. Summary of results of hydropower resource assessment of the North Atlantic Hydrologic Region (HUC 1).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**5,659**	**873**	**222**	**4,564**
TOTAL HIGH POWER	**3,875**	**837**	**137**	**2,901**
High Head/High Power	**2,768**	**680**	**112**	**1,976**
Low Head/High Power	**1,107**	**157**	**25**	**925**
TOTAL LOW POWER	**1,784**	**36**	**85**	**1,663**
High Head/Low Power	**1,192**	**10**	**68**	**1,114**
Low Head/Low Power	**592**	**26**	**17**	**549**
Conventional Turbine	234	25	6	203
Unconventional Systems	83	0	5	78
Microhydro	275	1	6	268

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

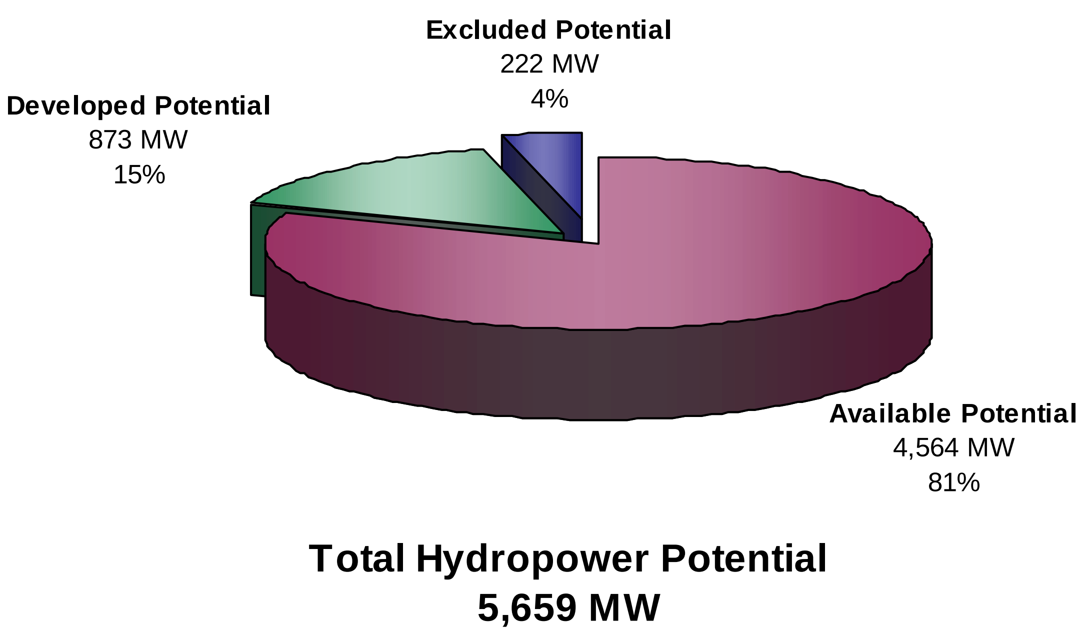

Figure A-2. Distribution of total hydropower potential in the North Atlantic Hydrologic Region (HUC 1).

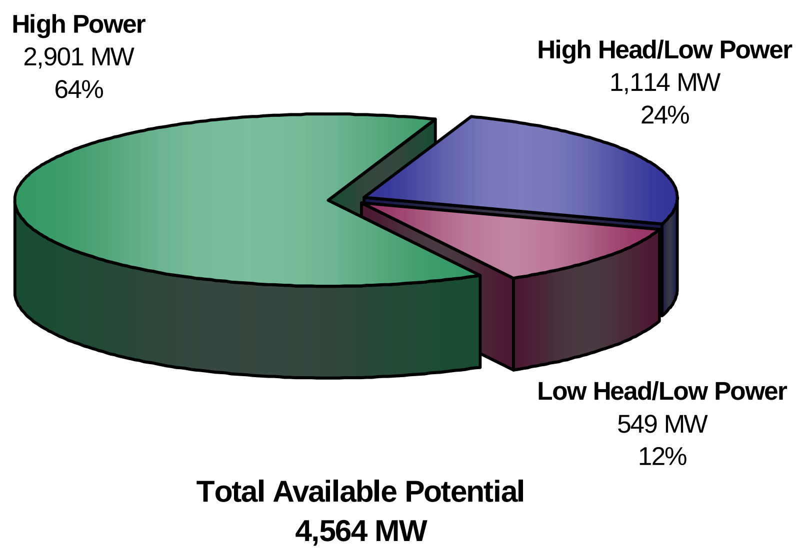

Figure A-3. Distribution of available hydropower potential in the North Atlantic Hydrologic Region (HUC 1).

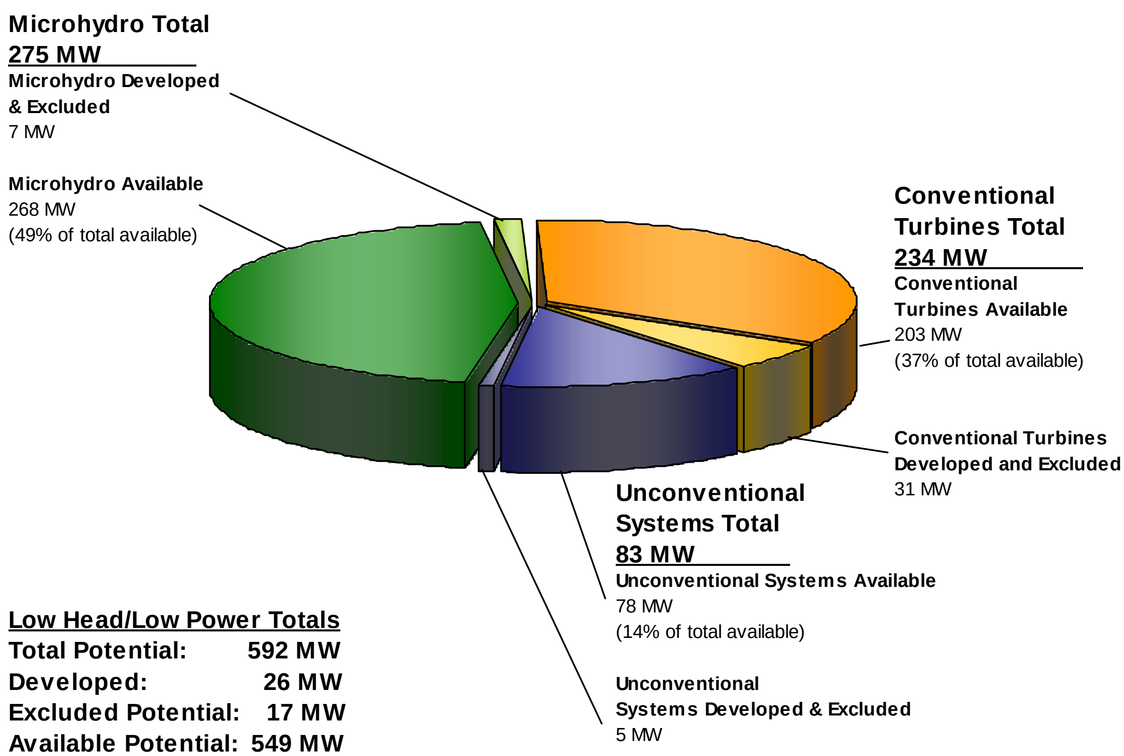

Figure A-4. Distribution of low head/low power hydropower potential in the North Atlantic Region (HUC 1) among three low head/low power hydropower technology classes.

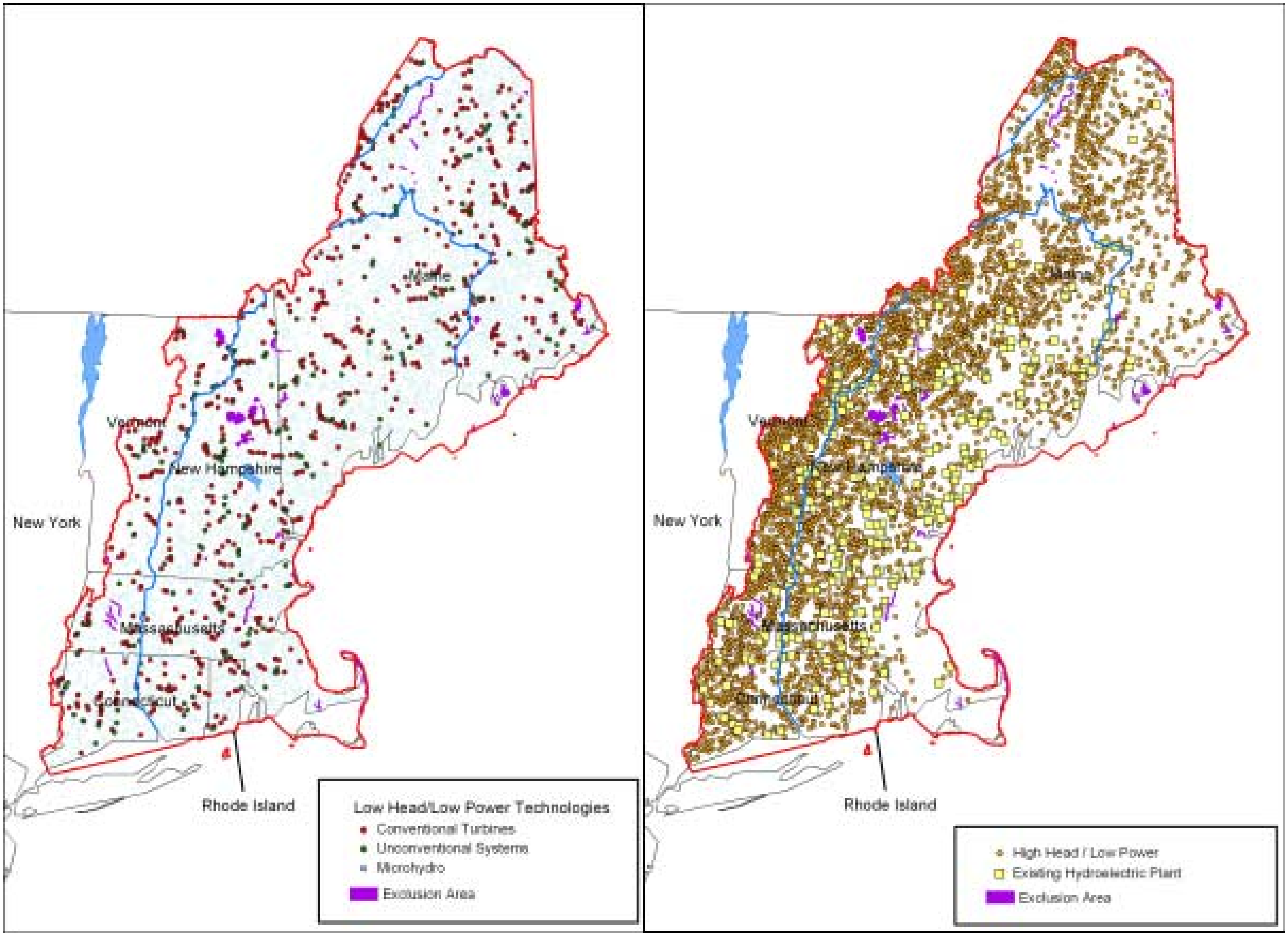

Figure A-5. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the North Atlantic Region HUC 1).

A.2 Middle Atlantic Hydrologic Region

A.2.1 Region Description

The topographic and hydrographic features of the Middle Atlantic Region are shown in Figure A-6. The Middle Atlantic Region covers approximately half of the states of Vermont, New York, and Pennsylvania, the entirety of the states of New Jersey and Delaware, most of the State of Maryland, and parts of the states of Virginia and West Virginia. The principal geographic features of this region (from east to west) are the Atlantic Coastal Plain, the Piedmont, and the Appalachian Mountains. Inland from the Atlantic Coastal Plain lies the Piedmont, a relatively low, rolling plateau that extends the entire length of the Middle Atlantic Region. The Piedmont is a fertile agricultural region crossed by many rivers originating in the Appalachian Mountains. The Piedmont rises to meet the Appalachians, a major mountain chain that runs from Maine to Alabama. A principal feature of the Appalachian Mountains from New York state southward is the ridge and valley sequence, a northeast-trending series of alternating ridges and valleys formed by the folding and erosion of parallel rock layers.

Several major rivers originate in the Appalachians, flowing across the Piedmont to bays and inlets on the Atlantic coast. These include (from north to south) the Hudson River, the Delaware River, the Susquehanna River, and the Potomac River. Many of these rivers are navigable and provided some of the earliest transportation corridors from the eastern United States to the interior of North America.

The climate of the region is temperate with abundant rainfall throughout the year. Temperatures are moderate near the southern coastal areas of the region, becoming cooler as one travels northward toward New York or inland from the coast.

A.2.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

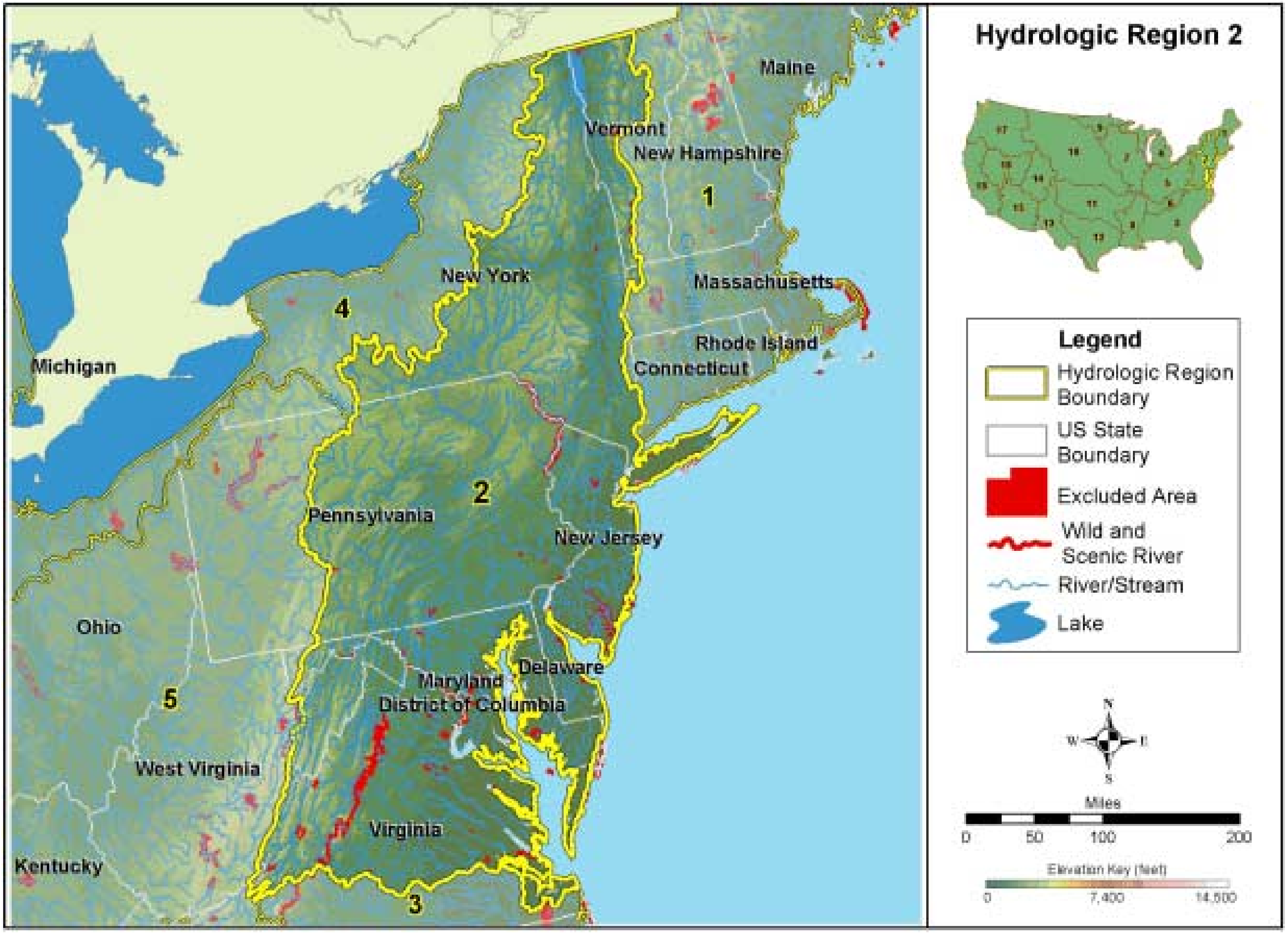

Figure A-6. Middle Atlantic Hydrologic Region (HUC 2).

Table A-2. Summary of results of hydropower resource assessment of the Middle Atlantic Hydrologic Region (HUC 2).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**9,254**	**839**	**798**	**7,617**
TOTAL HIGH POWER	**6,147**	**824**	**674**	**4,649**
High Head/High Power	**3,827**	**745**	**312**	**2,770**
Low Head/High Power	**2,320**	**79**	**362**	**1,879**
TOTAL LOW POWER	**3,107**	**15**	**124**	**2,968**
High Head/Low Power	**2,073**	**7**	**94**	**1,972**
Low Head/Low Power	**1,034**	**8**	**30**	**996**
Conventional Turbine	415	8	10	397
Unconventional Systems	139	0	6	133
Microhydro	480	0	14	466

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

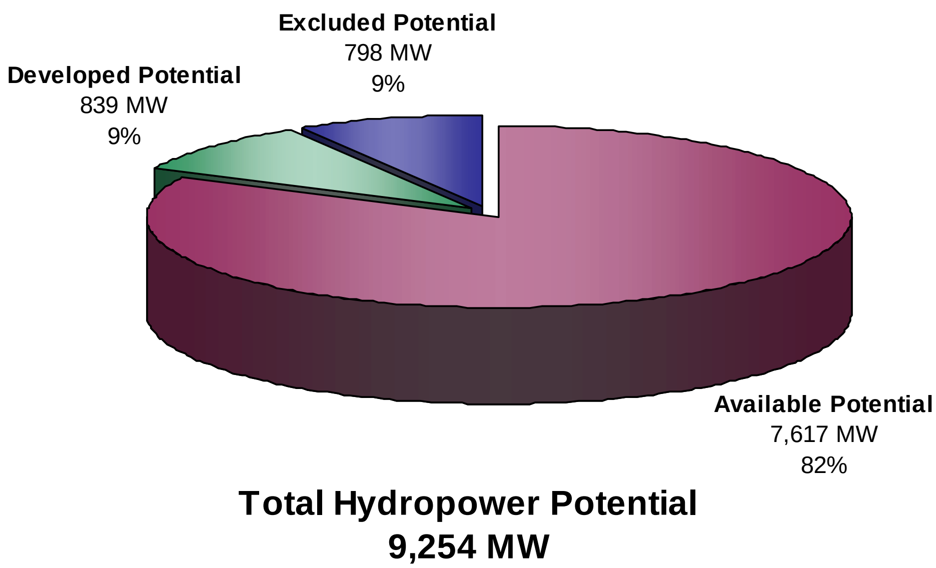

Figure A-7. Distribution of total hydropower potential in the Middle Atlantic Hydrologic Region (HUC 2).

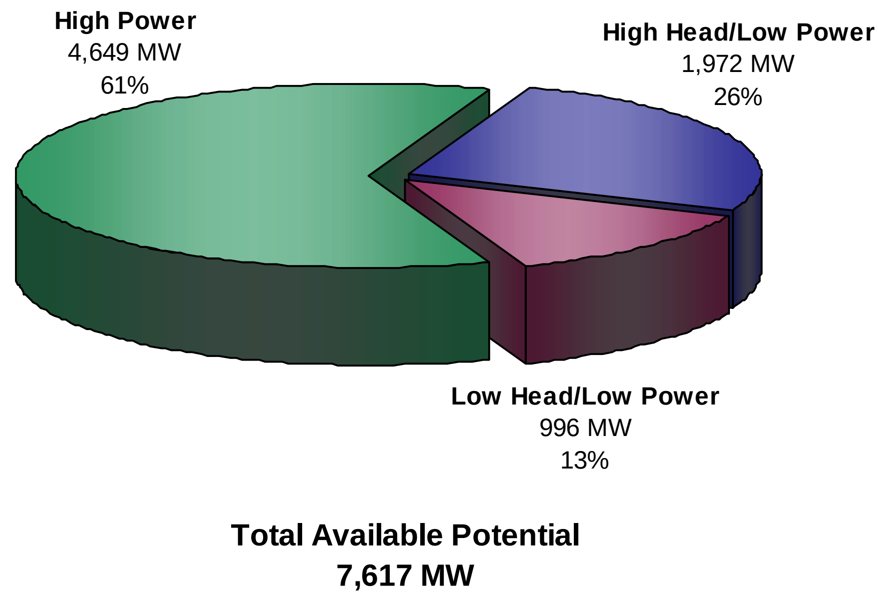

Figure A-8. Distribution of available hydropower potential in the Middle Atlantic Hydrologic Region (HUC 2).

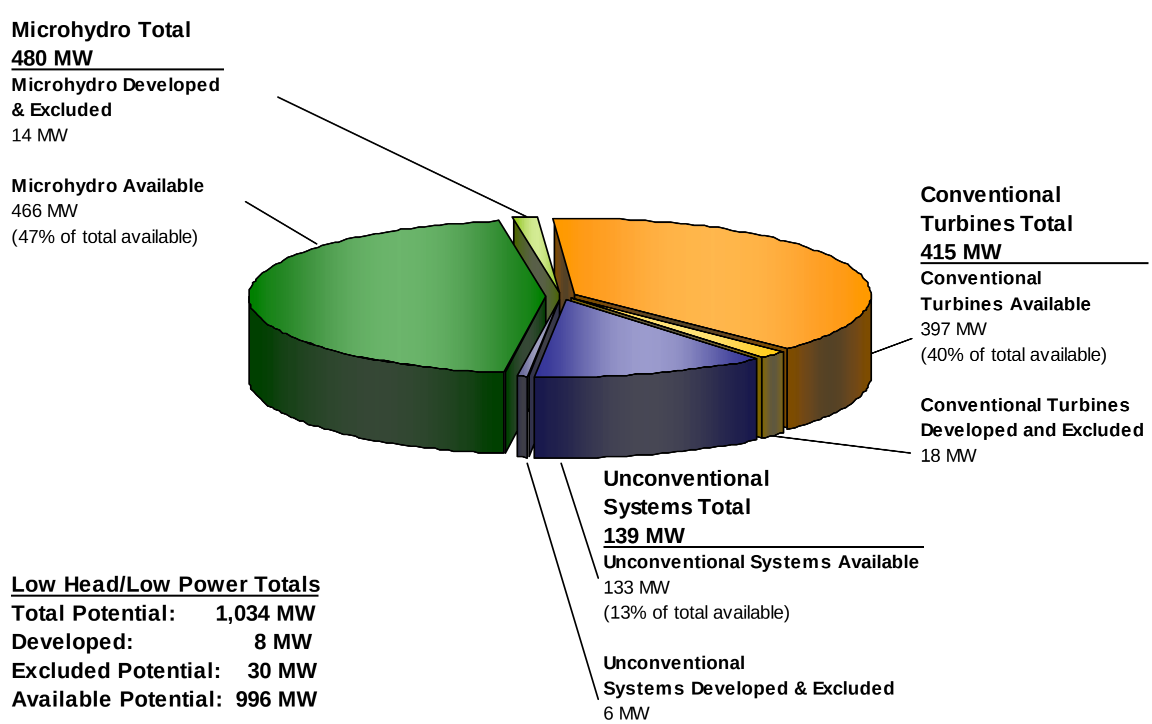

Figure A-9. Distribution of low head/low power hydropower potential in the Middle Atlantic Region (HUC 2) among three low head/low power hydropower technology classes.

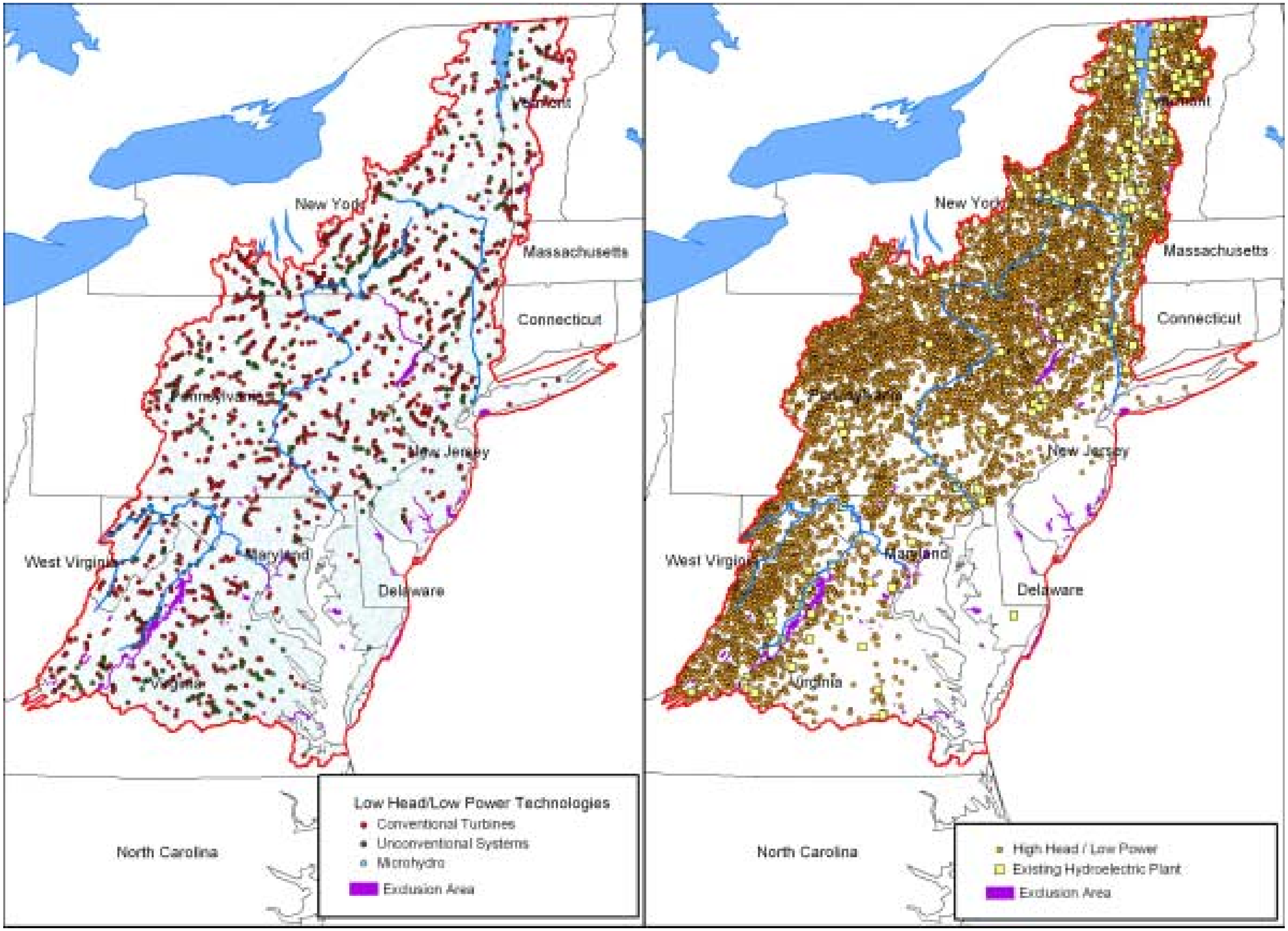

Figure A-10. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Middle Atlantic Region (HUC 2).

A.3 South Atlantic-Gulf Region

A.3.1 Region Description

The topographic and hydrographic features of the South Atlantic-Gulf Region are shown in Figure A-11. The region includes all watersheds from southern Virginia to Mississippi that drain to the Atlantic Ocean or the Gulf of Mexico. A broad, flat, extensive coastal plain underlies most of the region. The plain is composed of the Atlantic Coastal Plain and the Gulf Coastal Plain along the Atlantic and Gulf coasts, respectively. These plains extend beyond the water's edge to form a wide continental shelf, sometimes extending hundreds of miles offshore. In Virginia, North Carolina, Georgia, and Alabama, the plain transitions inland through a hilly upland area known as the Piedmont, with some river headwaters extending into the southern Appalachian Mountains. There are no mountains in other portions of the region, such as eastern Mississippi and southeastern Louisiana, South Carolina, and Florida.

The region contains numerous moderate-sized rivers, but no major rivers. The rivers generally follow parallel courses from the highlands to the sea. Bays indent much of the coastline, and barrier islands separate many of the bays from the open water, especially in North Carolina and Florida. The folded rock layers of the southern Appalachians occupy the northern border of the region, while the main coastal plain is underlain by thick, mostly horizontal sedimentary layers. Limestone is found in much of the Florida peninsula; in many areas groundwater has dissolved the limestone to produce sinkholes. The flat topography and high rainfall has created areas of poor drainage such as the Okefenokee Swamp of southern Georgia and the Florida Everglades.

The climate in the South Atlantic-Gulf Region ranges from temperate in the north to subtropical in south Florida. Mountains and the northern part of the region can see winter snows, but the remainder of the region has mild winters and hot, humid summers. The entire region is subject to tropical storms and hurricanes.

A.3.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

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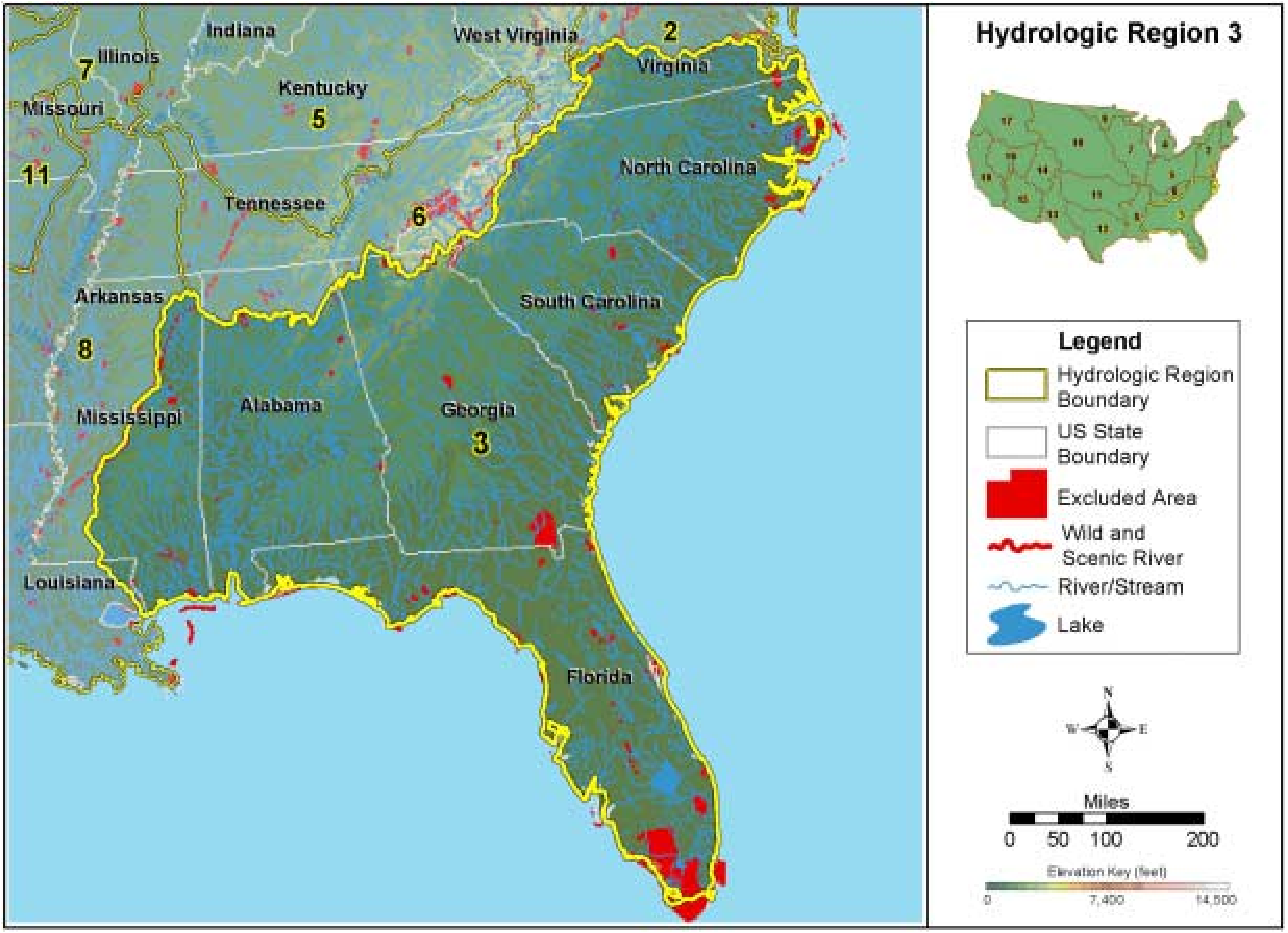


Figure A-11. South Atlantic-Gulf Region (HUC 3).

Table A-3. Summary of results of hydropower resource assessment of the South Atlantic-Gulf Region (HUC 3).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**8,661**	**1,849**	**453**	**6,359**
TOTAL HIGH POWER	**5,560**	**1,837**	**370**	**3,353**
High Head/High Power	**2,930**	**1,803**	**259**	**868**
Low Head/High Power	**2,630**	**34**	**111**	**2,485**
TOTAL LOW POWER	**3,101**	**12**	**83**	**3,006**
High Head/Low Power	**781**	**4**	**31**	**746**
Low Head/Low Power	**2,320**	**8**	**52**	**2,260**
Conventional Turbine	773	8	17	748
Unconventional Systems	527	0	20	507
Microhydro	1,020	0	15	1,005

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

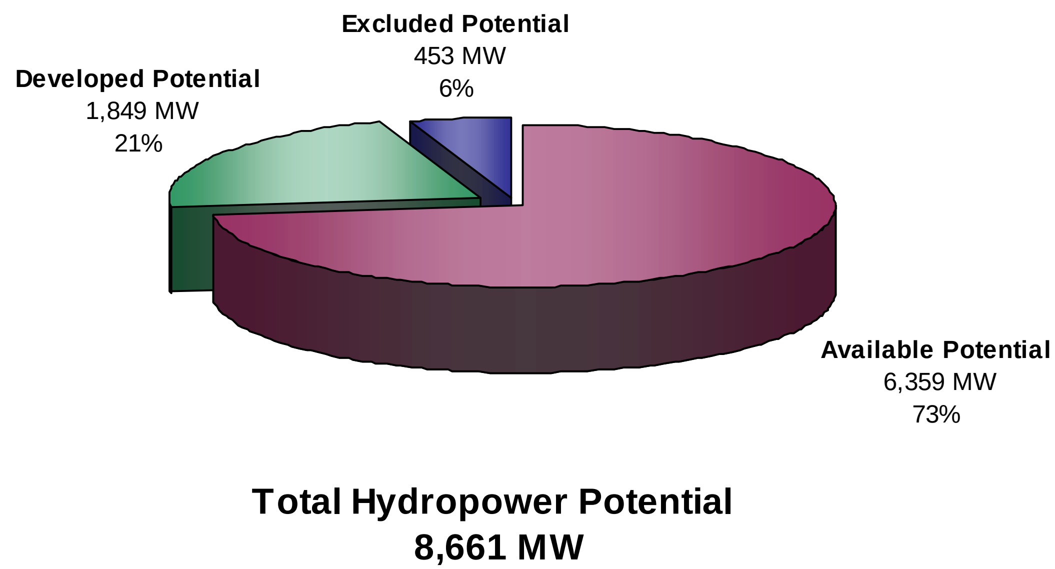


Figure A-12. Distribution of total hydropower potential in the South Atlantic-Gulf Region (HUC 3).

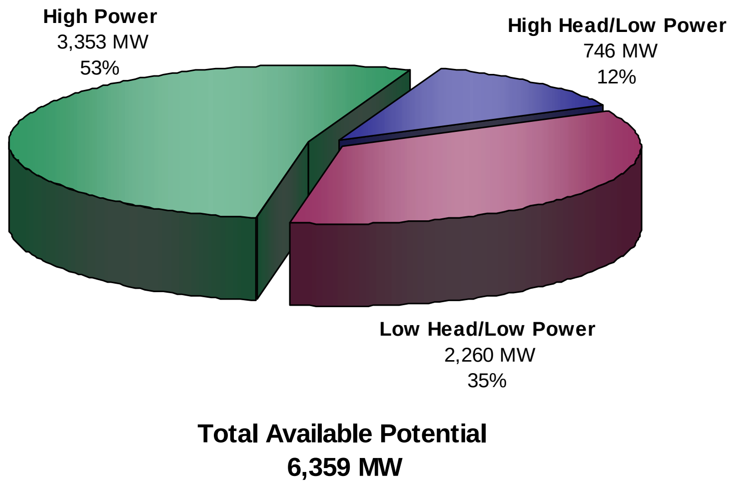


Figure A-13. Distribution of available hydropower potential in the South Atlantic-Gulf Hydrologic Region (HUC 3).

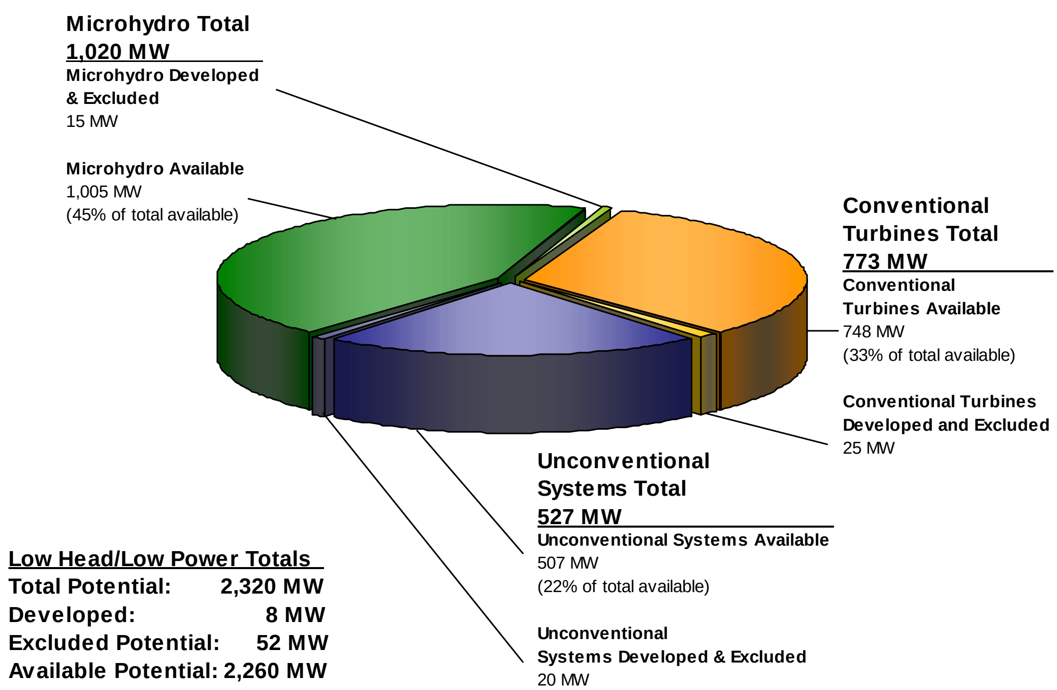


Figure A-14. Distribution of low head/low power hydropower potential in the South Atlantic-Gulf Region (HUC 3) among three low head/low power hydropower technology classes.

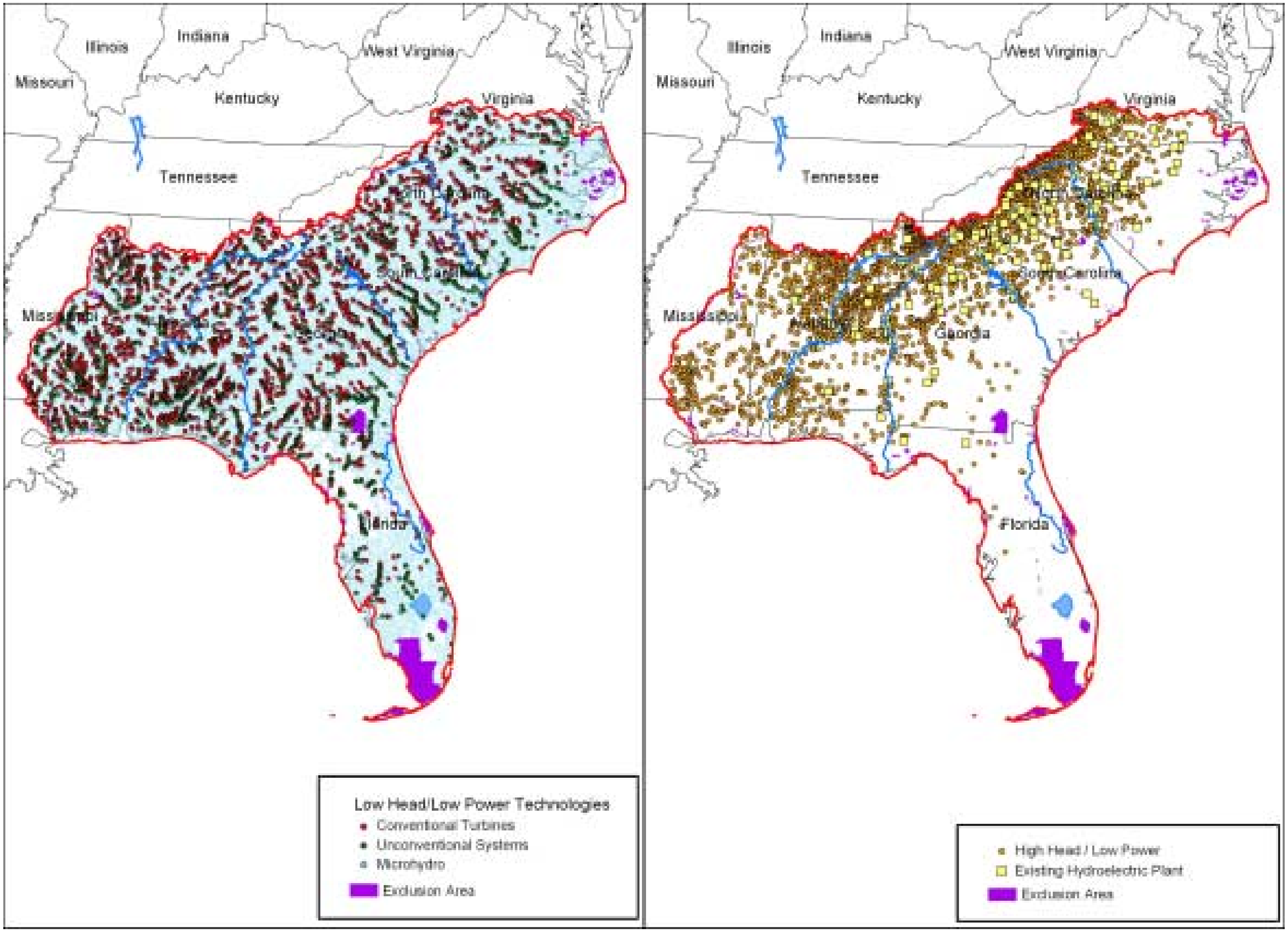


Figure A-15. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the North Atlantic Region (HUC 3).

A.4 Great Lakes Region

A.4.1 Region Description

The topographic and hydrographic features of the Great Lakes Region are shown in Figure A-16. The region extends approximately 1,000 miles from east to west encompassing the watershed along the United States shoreline of the five Great Lakes as well as a portion of the St. Lawrence River watershed. The region includes nearly all of Michigan as well as parts of Minnesota, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, and western New York. In general, these watersheds do not extend far inland from the lakeshore, which is unusual considering the vast size of the lakes themselves. Near Chicago, Illinois, streams only a few miles from Lake Michigan flow to the Gulf of Mexico rather than the nearby lake.

The principal water bodies of the region are the Great Lakes: Lake Superior, Lake Huron, Lake Michigan, Lake Erie, and Lake Ontario. Principal rivers include the rivers connecting the lakes, such as the Niagara, St. Clair, Detroit, and Ste. San Marie Rivers. Canals connect the Great Lakes to the tributaries of the Mississippi and Hudson Rivers, enabling navigation from the lakes to the Atlantic Ocean and the Gulf of Mexico. Hydropower projects in the area often take advantage of the elevation differences between the lakes. For example, much of the Niagara River is diverted upstream of Niagara Falls for hydropower production.

The landscape is generally flat, with coniferous forests in the north and mixed farmland/deciduous woodland in the south. The region contains many ice age glacial remnants such as outwash deposits and moraines. The Great Lakes Region includes many urban and industrial centers including Chicago, Illinois; Detroit, Michigan; and Cleveland, Ohio. Climate in the region is continental, with cold winters (severe in the north) and warm to hot, humid summers.

A.4.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

For this region, the high head/high power available power based on power category summation was negative possibly because of an underestimation of total hydropower potential or overestimation of developed power potential. The value was set to zero resulting in available high power being equal to the low head/high power constituent. The total available potential value was set equal to the sum of its power class constituents (high power and low power) instead of the sum by power category.

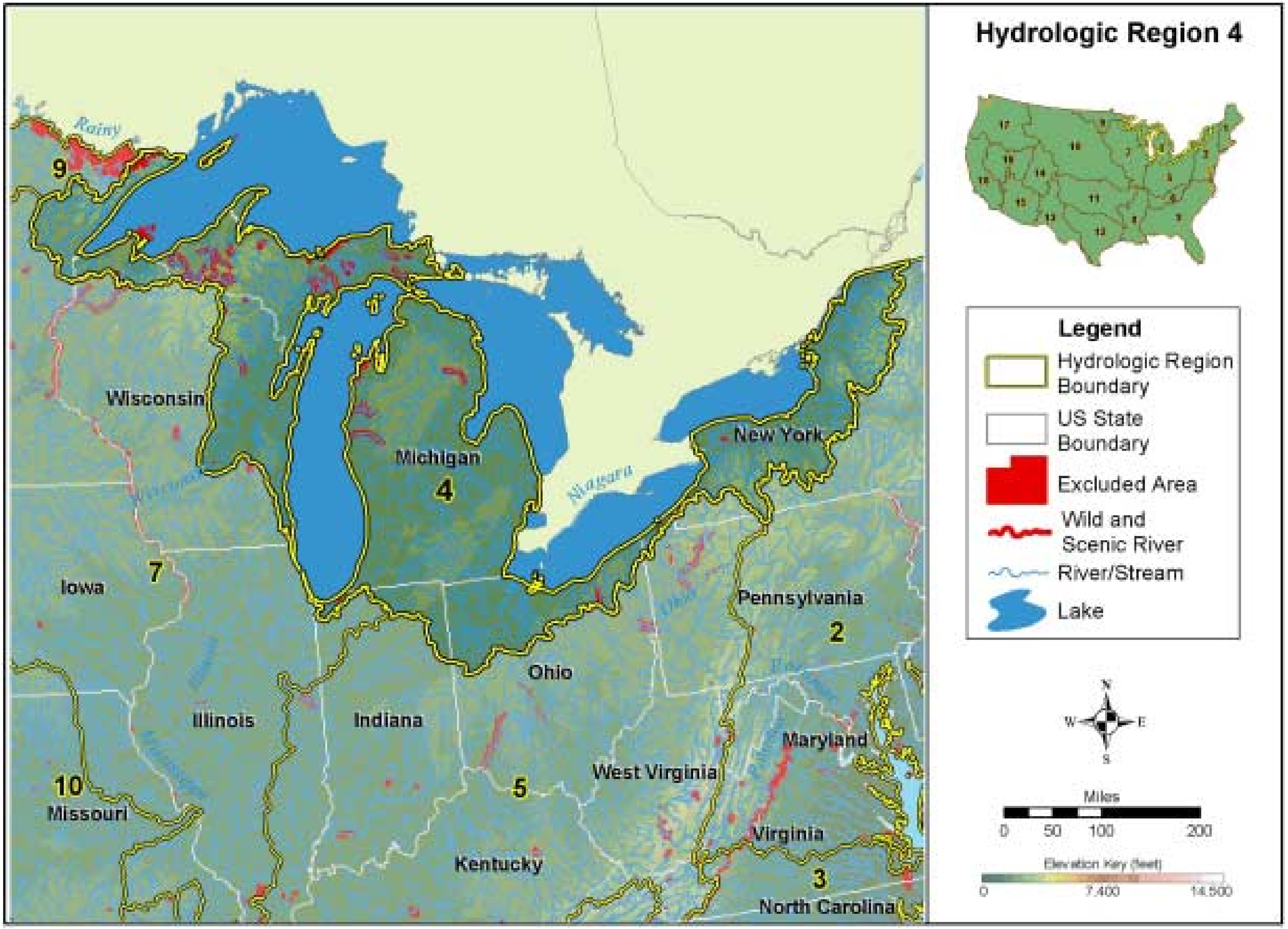


Figure A-16. Great Lakes Region (HUC 4).

Table A-4. Summary of results of hydropower resource assessment of the Great Lakes Region (HUC 4).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**4,353**	**2,853**	**271**	**1841**
TOTAL HIGH POWER	**2,594**	**2,832**	**166**	**208**
High Head/High Power	**2,177**	**2,641**	**148**	**—**
Low Head/High Power	**417**	**191**	**18**	**208**
TOTAL LOW POWER	**1,759**	**21**	**105**	**1,633**
High Head/Low Power	**779**	**4**	**42**	**733**
Low Head/Low Power	**980**	**17**	**63**	**900**
Conventional Turbine	368	17	34	317
Unconventional Systems	143	0	11	132
Microhydro	469	0	18	451

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

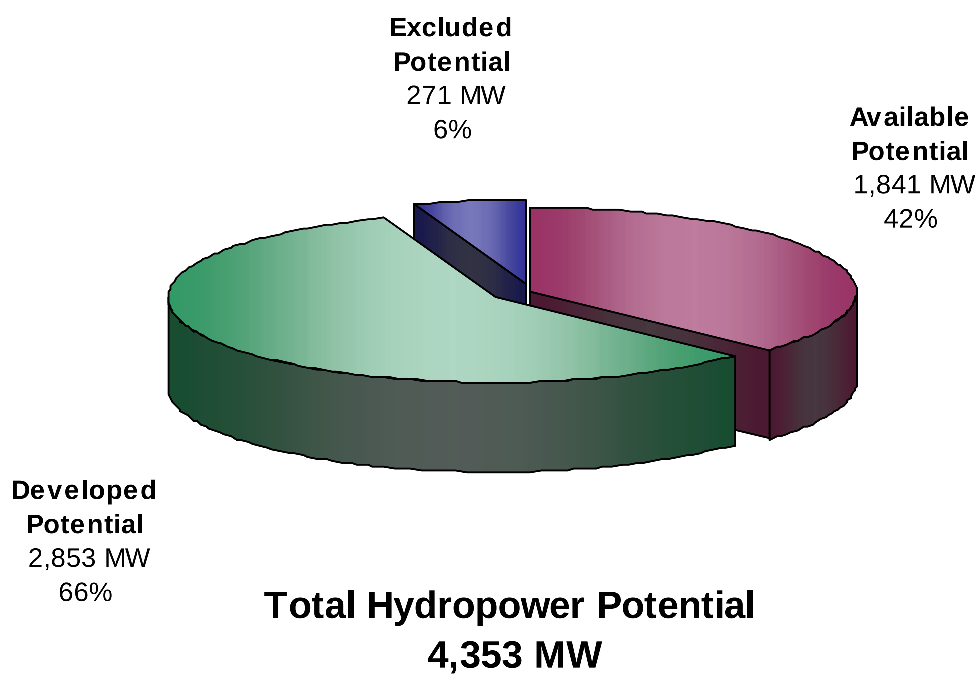


Figure A-17. Distribution of total hydropower potential in the Great Lakes Region (HUC 4).

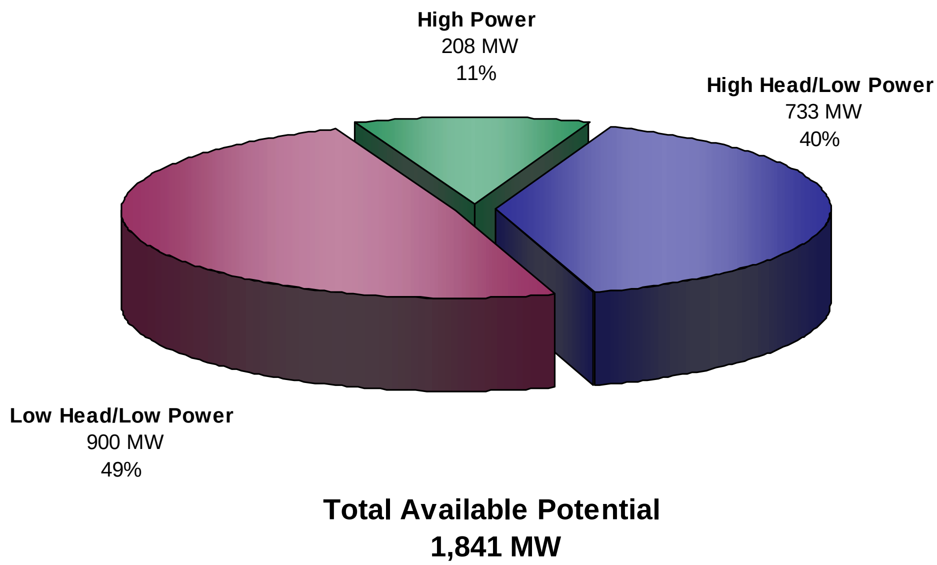


Figure A-18. Distribution of available hydropower potential in the Great Lakes Hydrologic Region (HUC 4).

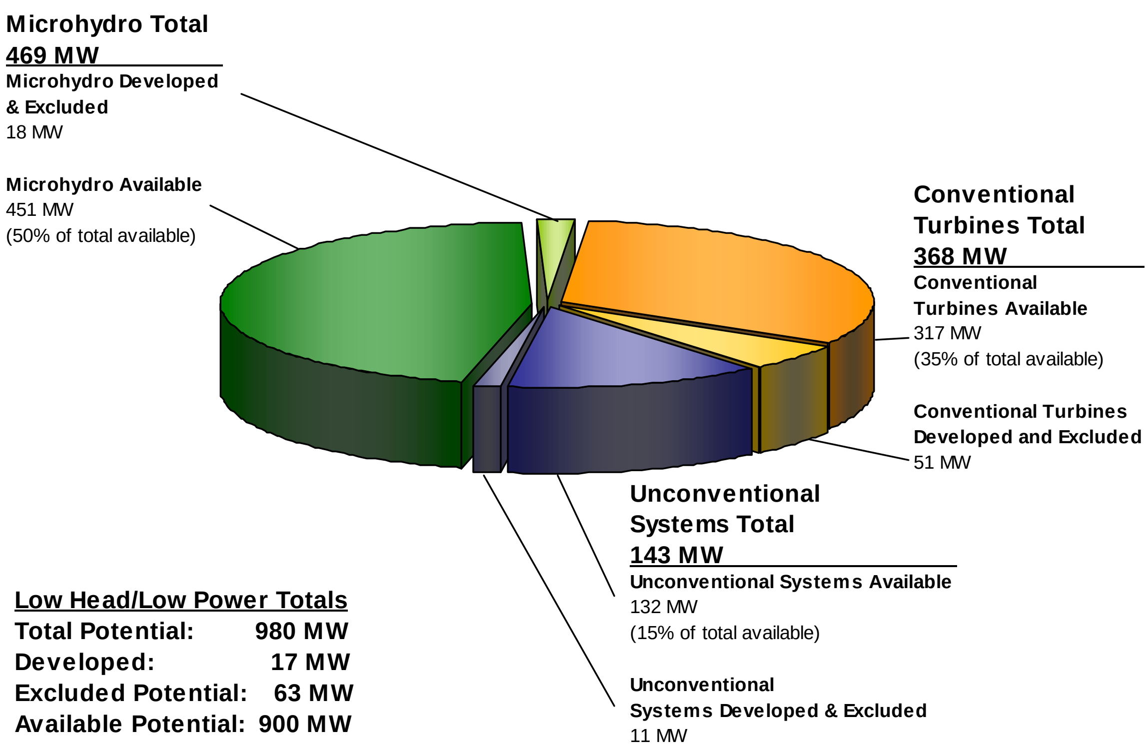


Figure A-19. Distribution of low head/low power hydropower potential in the Great Lakes Region (HUC 4) among three low head/low power hydropower technology classes.

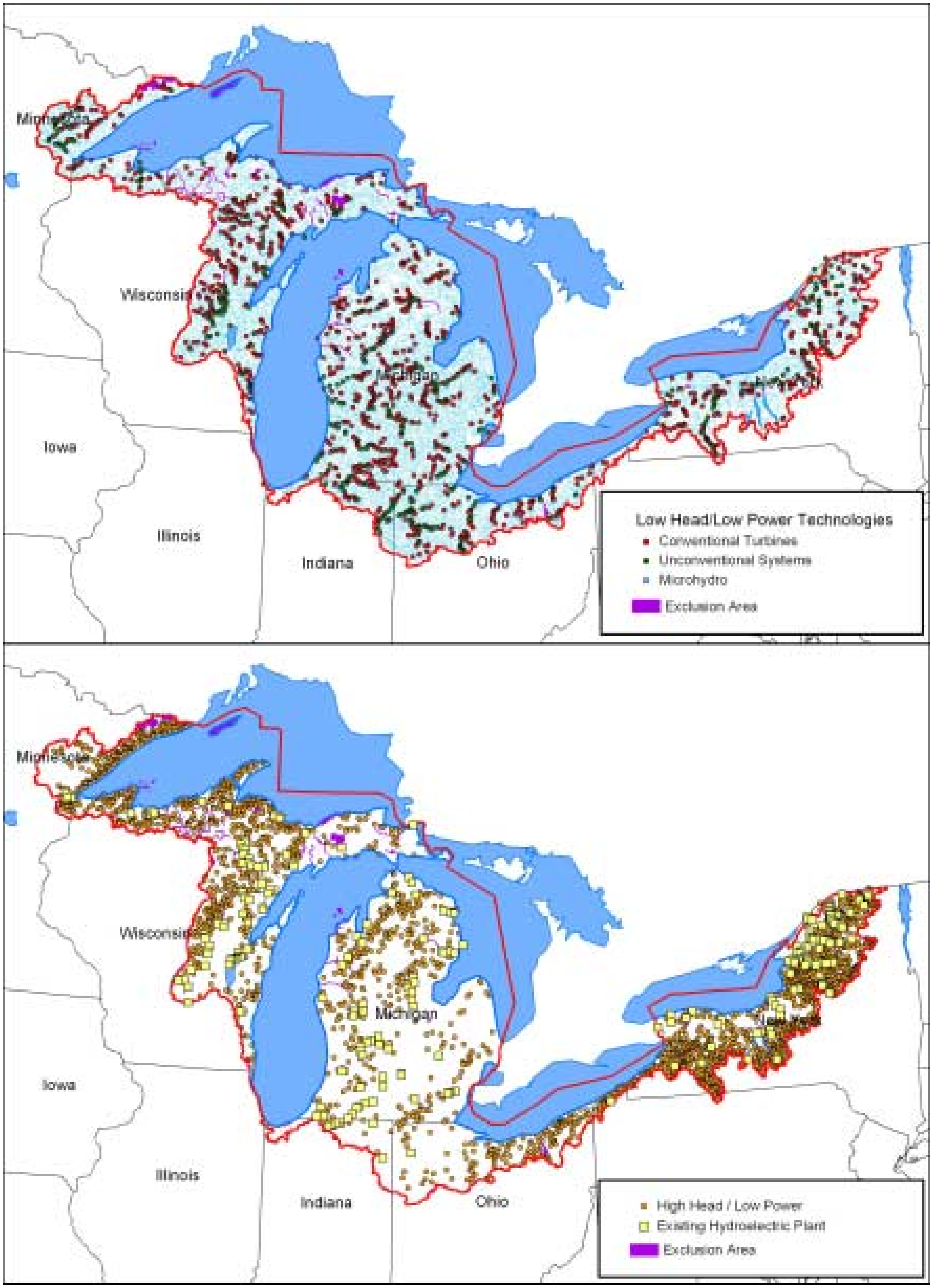


Figure A-20. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Great Lakes Region (HUC 4).

A.5 Ohio Region

A.5.1 Region Description

The topographic and hydrographic features of the Ohio Region are shown in Figure A-21. The region covers the entire Ohio River watershed, except for the Tennessee and Cumberland River drainage basins. It extends from the thickly wooded Appalachian Mountains in the north through mixed farmland/deciduous woodland of the Ohio Valley to the Mississippi River. The region encompasses most of Ohio, Indiana, Kentucky, and West Virginia as well as portions of Illinois, Tennessee, Virginia, Maryland, Pennsylvania, and New York. The Ohio River is navigable for much of its length serving as an inland waterway that links the Gulf of Mexico to the Great Lakes and the Atlantic Ocean. The climate is temperate to continental, with influences from both cold Canadian air masses and warm Gulf air masses. Winters can be cold, summers warm, and springs and autumns pleasant.

A.5.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

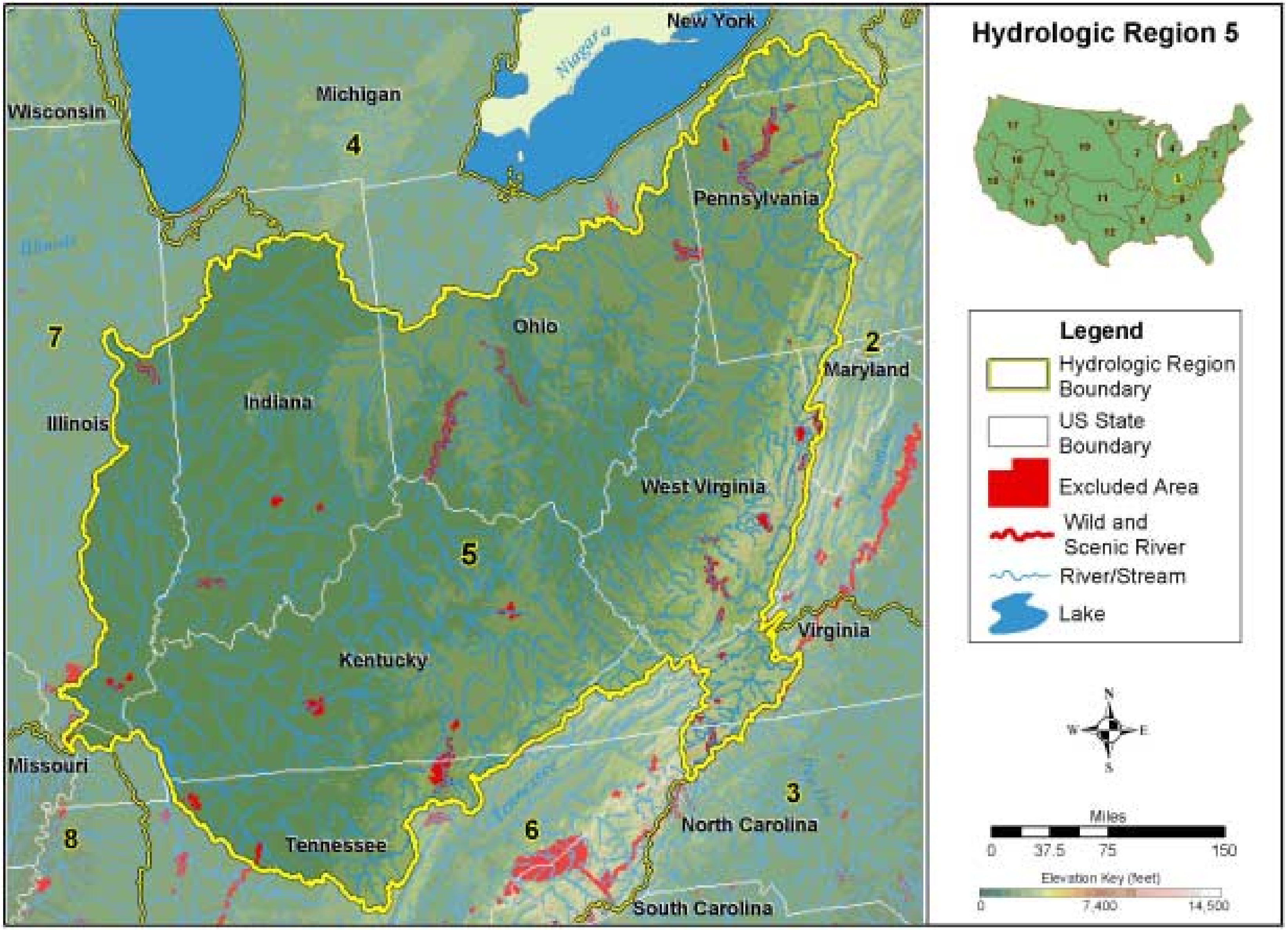


Figure A-21. Ohio Region (HUC 5).

Table A-5. Summary of results of hydropower resource assessment of the Ohio Region (HUC 5).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**12,109**	**820**	**1,275**	**10,014**
TOTAL HIGH POWER	**9,212**	**819**	**1,144**	**7,249**
High Head/High Power	**4,120**	**675**	**807**	**2,638**
Low Head/High Power	**5,092**	**144**	**337**	**4,611**
TOTAL LOW POWER	**2,897**	**1**	**131**	**2,765**
High Head/Low Power	**1,298**	**0**	**78**	**1,220**
Low Head/Low Power	**1,599**	**1**	**53**	**1,545**
Conventional Turbine	592	1	24	567
Unconventional Systems	218	0	10	208
Microhydro	789	0	19	770

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

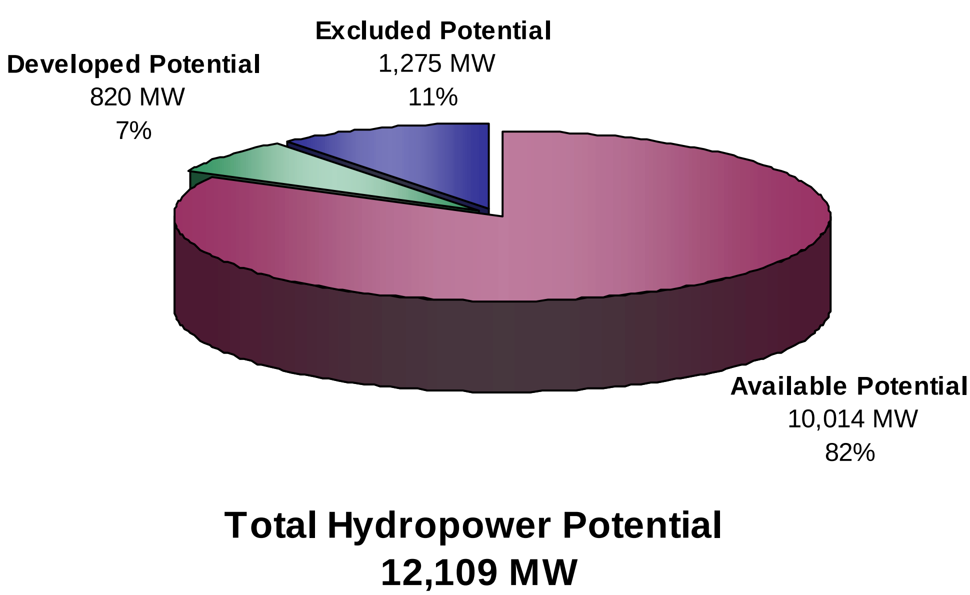


Figure A-22. Distribution of total hydropower potential in the Ohio Region (HUC 5).

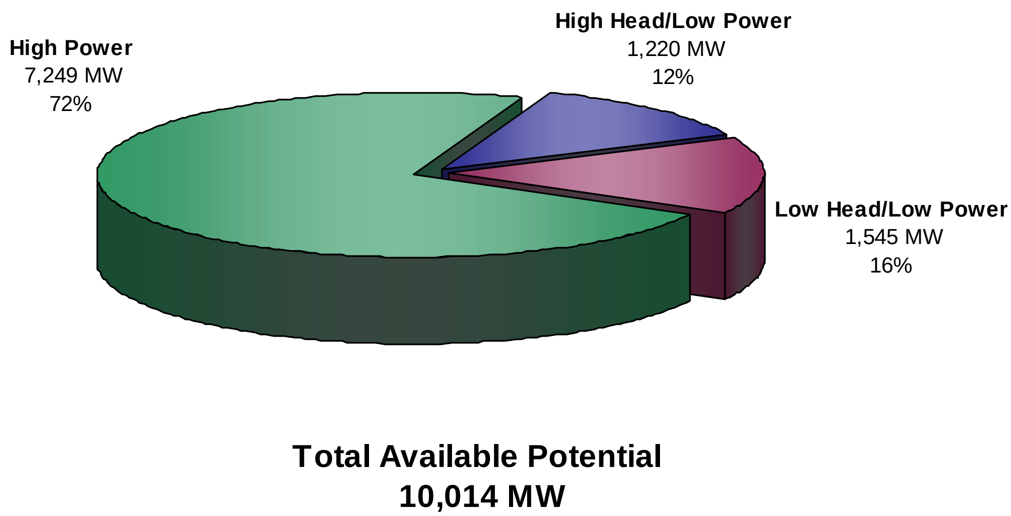


Figure A-23. Distribution of available hydropower potential in the Ohio Hydrologic Region (HUC 5).

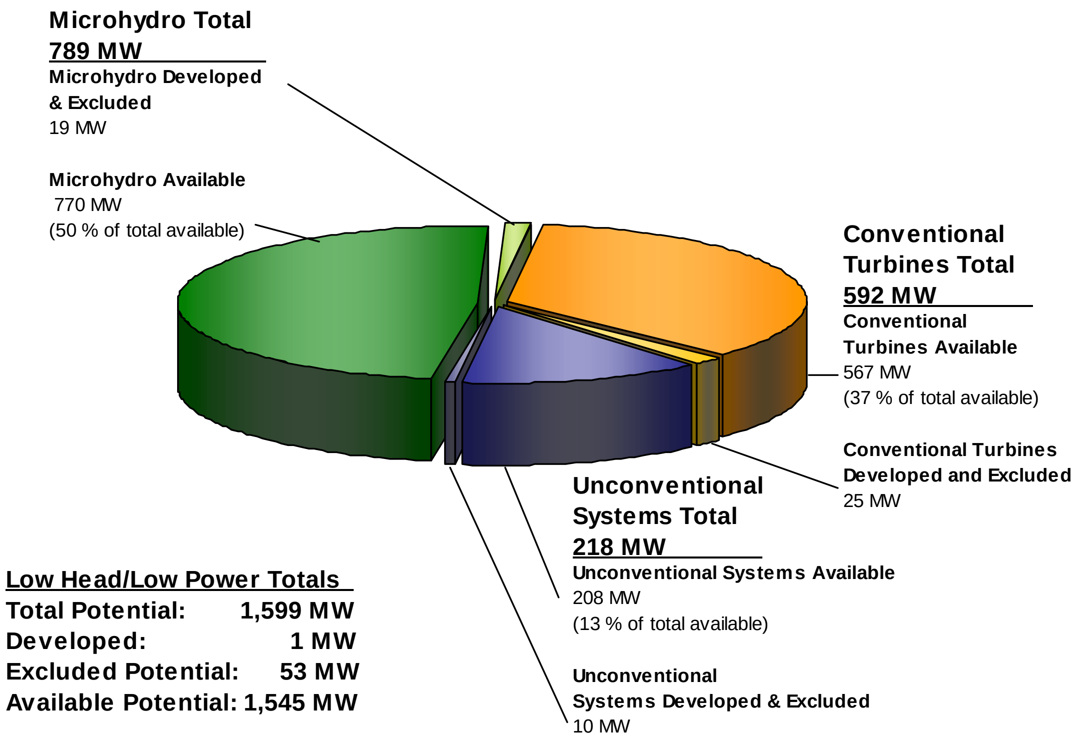


Figure A-24. Distribution of low head/low power hydropower potential in the Ohio Region (HUC 5) among three low head/low power hydropower technology classes.

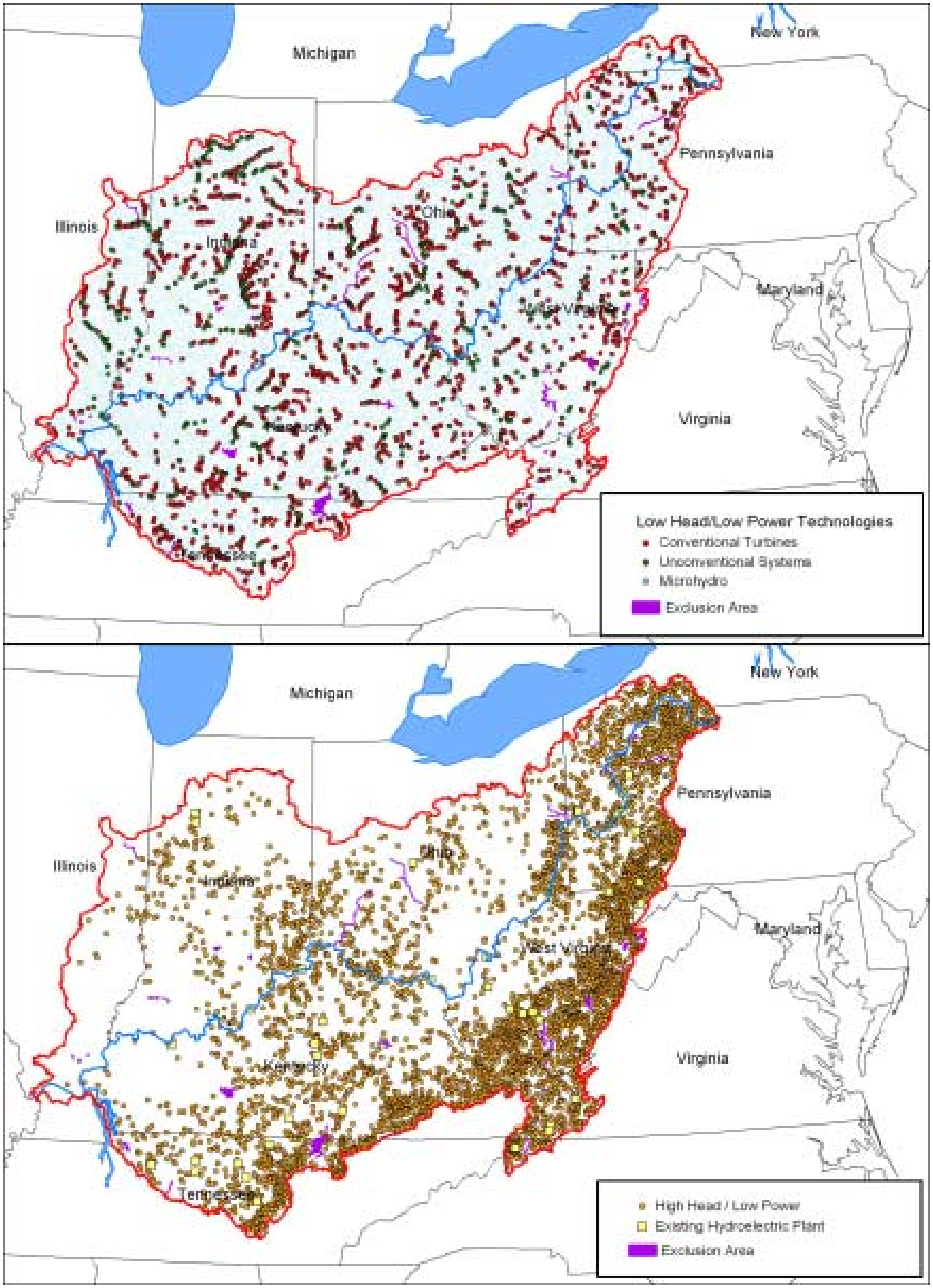


Figure A-25. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Ohio Region (HUC 5).

A.6 Tennessee Region

A.6.1 Region Description

The topographic and hydrographic features of the Tennessee Region are shown in Figure A-26. The region encompasses the Tennessee and Cumberland River watersheds, covering most of Tennessee and parts of Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi. The eastern end of the region includes the headwaters of the Cumberland River, in the Cumberland Plateau of the Appalachian Mountains. Rolling hills, deciduous woodland, grassland and river valleys dominate the remainder of the region. The climate is temperate, with ample precipitation.

Although small in area compared to other hydrologic regions, the Tennessee Region contains many of the nation's largest and best-known hydropower projects. The Tennessee Valley Authority, a federal agency created in the 1930s, constructed a series of dams, reservoirs, and power plants along the Tennessee, Cumberland, and other rivers in the region. They provide water storage, flood control, recreation, and hydropower to parts of the southeastern United States. For its size, the Tennessee Region has the highest concentration of hydropower development than any other region in the United States except the Pacific Northwest Region (HUC 17).

A.6.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

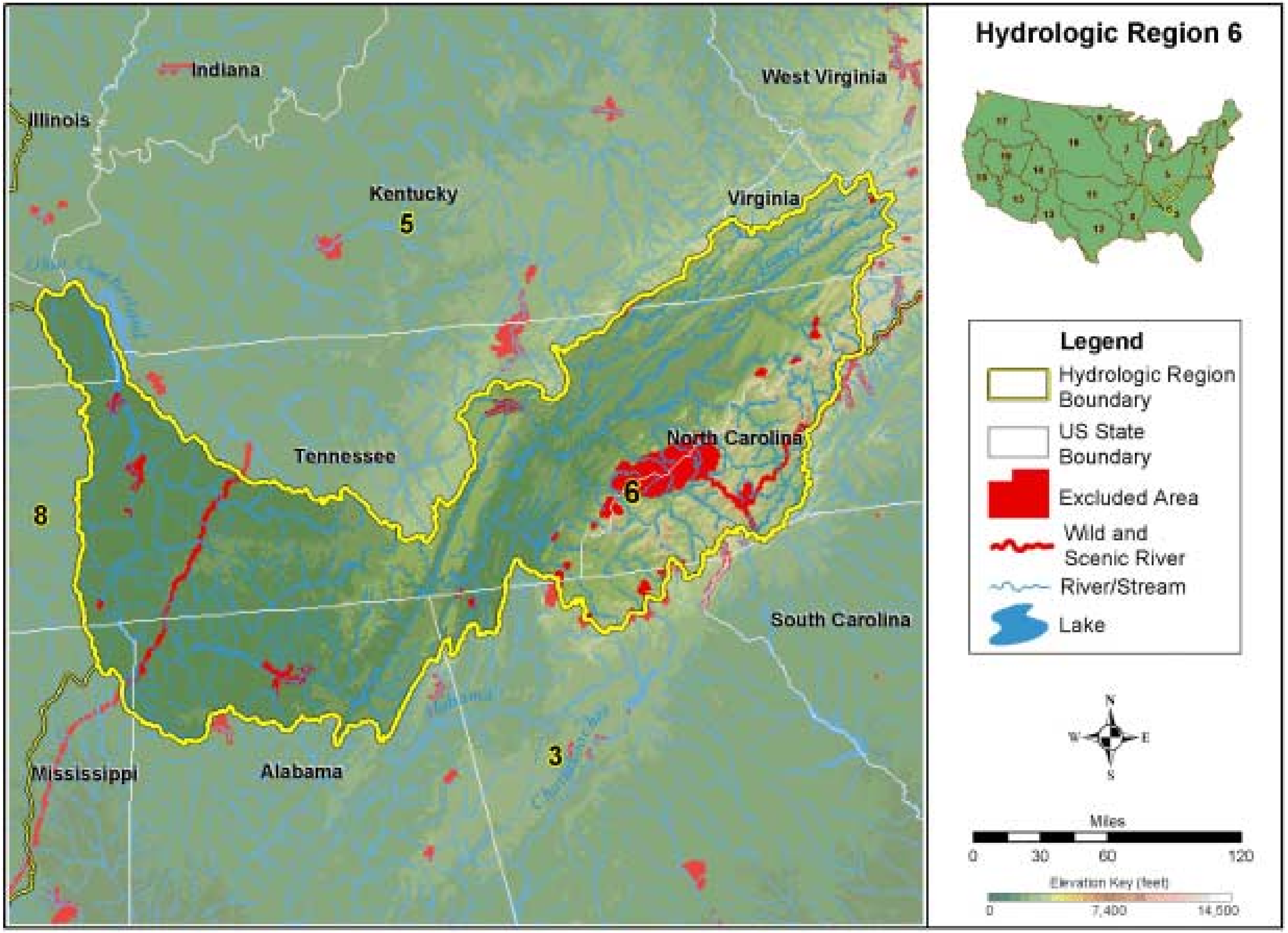


Figure A-26. Tennessee Region (HUC 6).

Table A-6. Summary of results of hydropower resource assessment of the Tennessee Region (HUC 6).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**5,075**	**1,858**	**743**	**2,474**
TOTAL HIGH POWER	**3,871**	**1,857**	**582**	**1,432**
High Head/High Power	**3,011**	**1,852**	**542**	**617**
Low Head/High Power	**860**	**5**	**40**	**815**
TOTAL LOW POWER	**1,204**	**1**	**161**	**1,042**
High Head/Low Power	**782**	**1**	**141**	**640**
Low Head/Low Power	**422**	**0**	**20**	**402**
Conventional Turbine	151	0	7	144
Unconventional Systems	67	0	3	64
Microhydro	204	0	10	194

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

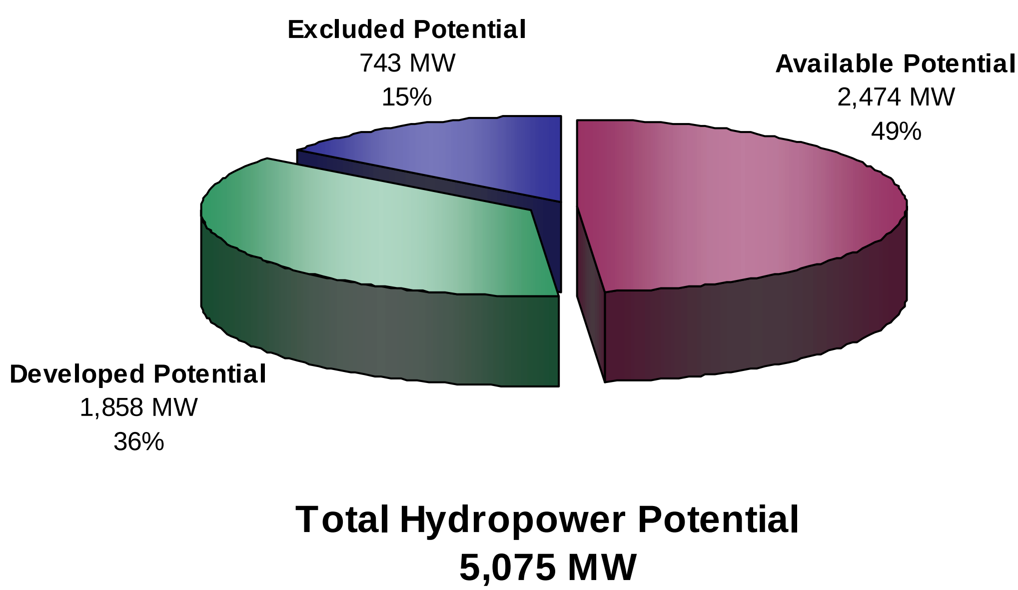


Figure A-27. Distribution of total hydropower potential in the Tennessee Region (HUC 6).

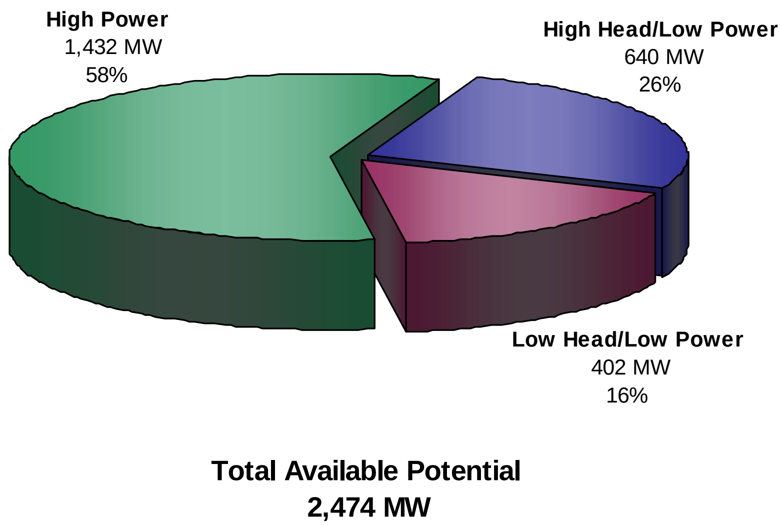


Figure A-28. Distribution of available hydropower potential in the Tennessee Hydrologic Region (HUC 6).

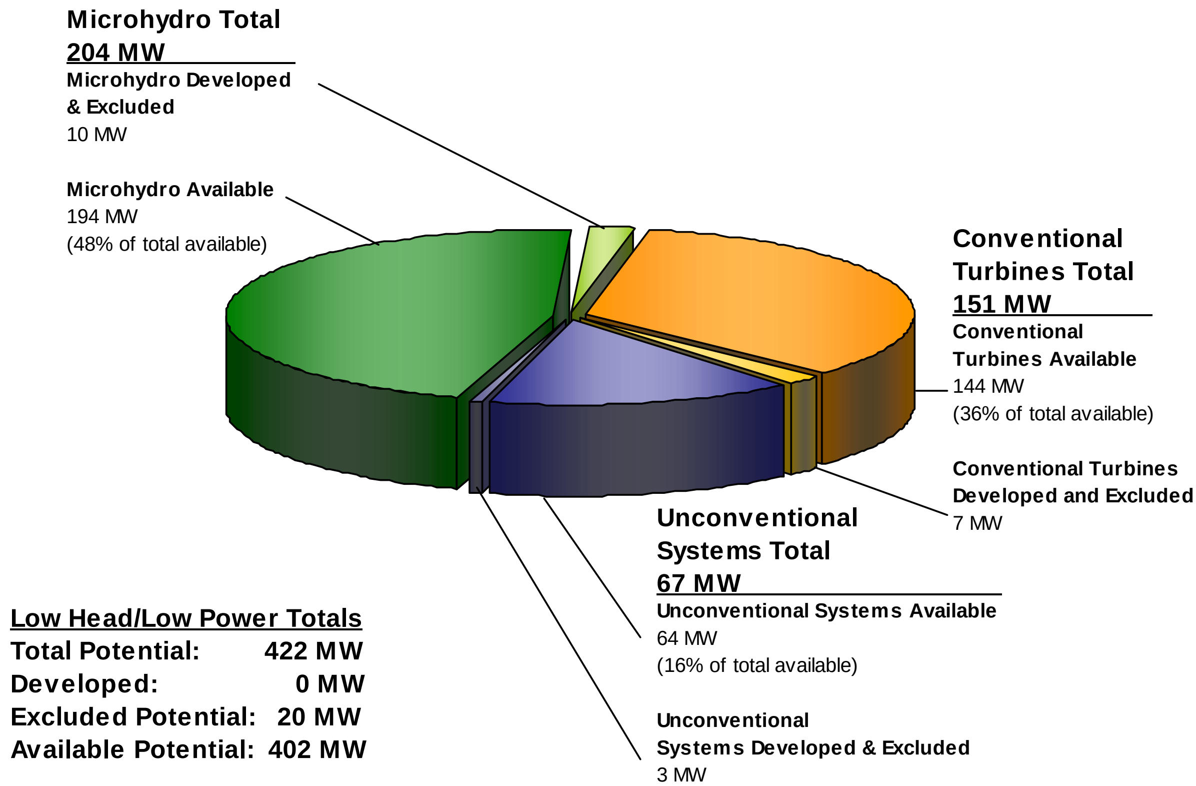


Figure A-29. Distribution of low head/low power hydropower potential in the Tennessee Region (HUC 6) among three low head/low power hydropower technology classes.

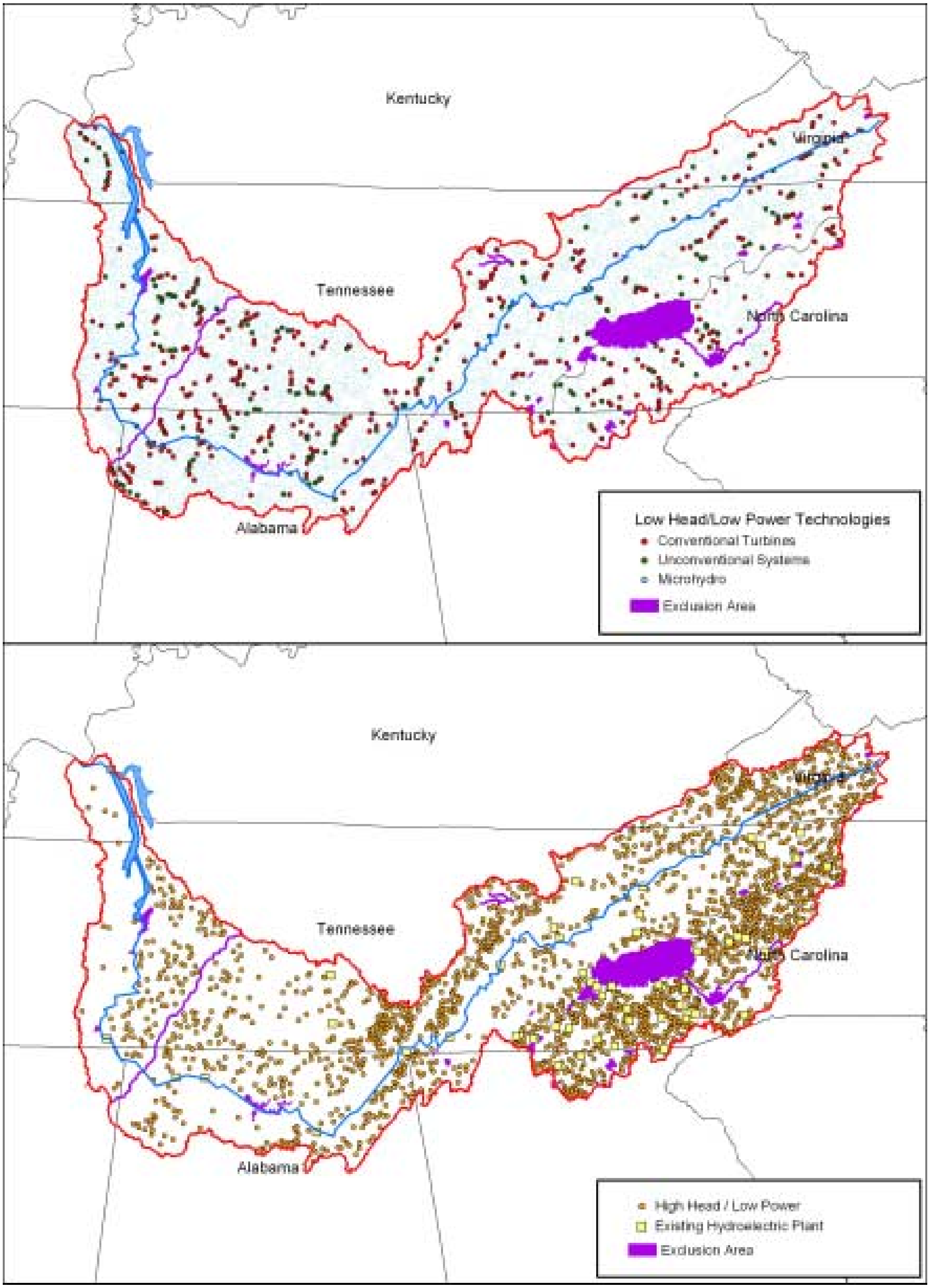


Figure A-30. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Tennessee Region (HUC 6).

A.7 Upper Mississippi Region

A.7.1 Region Description

The topographic and hydrographic features of the Upper Mississippi Region are shown in Figure A-31. The region consists of the Mississippi River watershed upstream of the Ohio River, excluding the Missouri River drainage. The region covers much of Illinois, Iowa, Minnesota, and Wisconsin, plus parts of Missouri, South Dakota, and Indiana. This area lies in the agricultural heartland of the United States.

The landscape consists primarily of rolling prairie with deep rich soils in many places. Glacial outwash and wind deposits underlie much of the region. The principal tributaries of the Mississippi River in this area are the Illinois, Des Moines, and Minnesota Rivers. The Mississippi River is navigable upstream to Minneapolis/St. Paul, Minnesota. Topographic relief is minor, with elevations generally less than 1,500 feet. However, bluffs of 300 to 400 feet line the Mississippi River floodplain in some places. In many places, man-made channels and levees line the banks of the Mississippi River. They serve to create a stable channel suitable for navigation and provide flood control for nearby lowlands. These levees have successfully contained the normal floods from inundating towns and farmland in the surrounding floodplain. However, sediment buildup in the river channel has required the levee heights to be raised, which raises the overall level of the river. In many places, the river surface is higher than the surrounding floodplain.

A.7.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

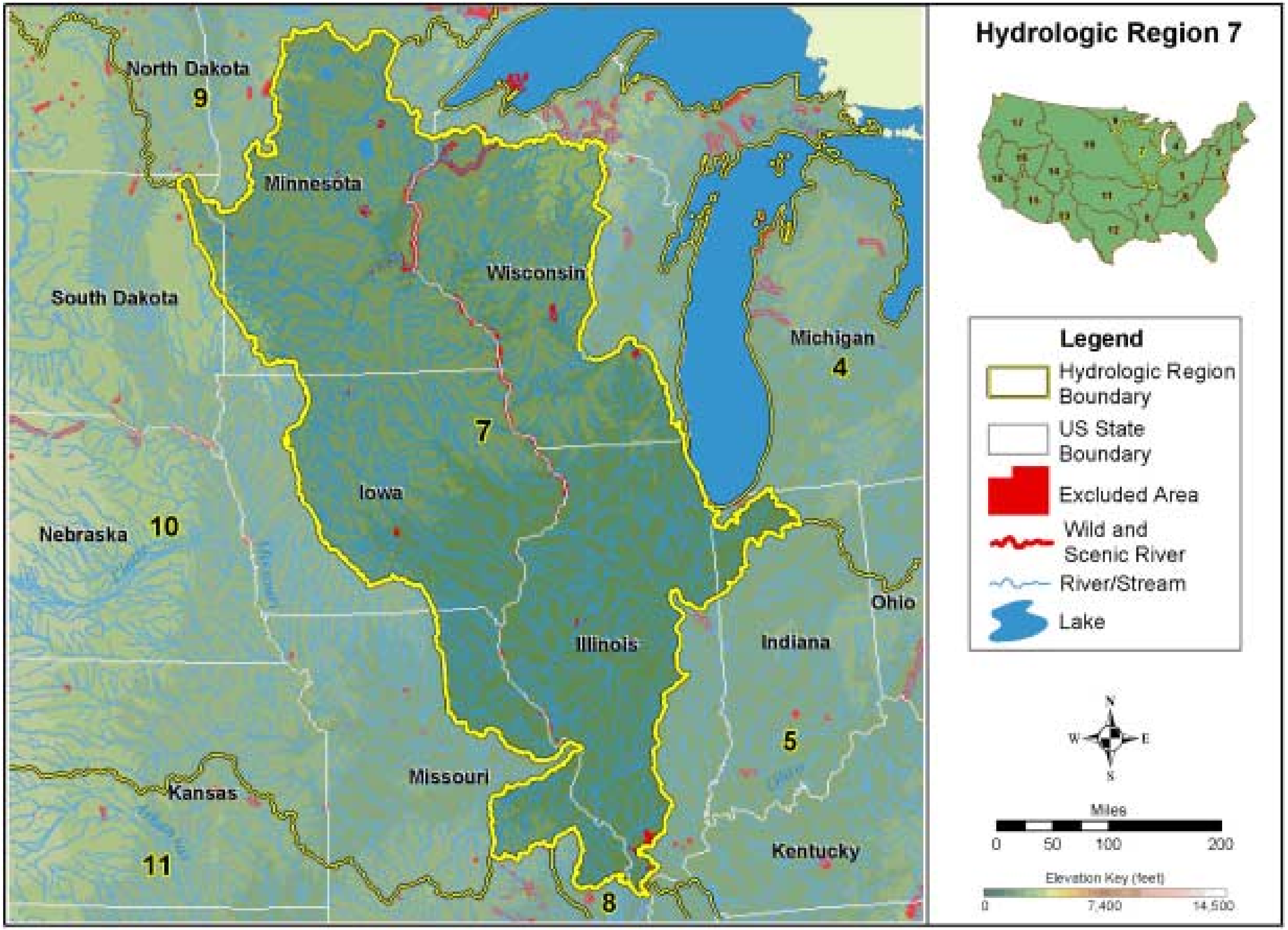
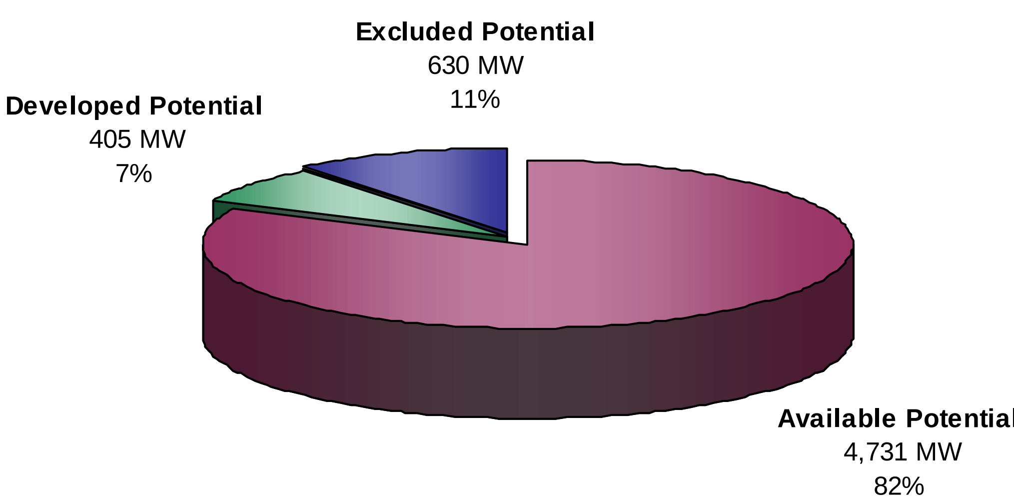


Figure A-31. Upper Mississippi Region (HUC 7).

Table A-7. Summary of results of hydropower resource assessment of the Upper Mississippi Region (HUC 7).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**5,766**	**405**	**630**	**4,731**
TOTAL HIGH POWER	**4,092**	**396**	**570**	**3,126**
High Head/High Power	**462**	**299**	**64**	**99**
Low Head/High Power	**3,630**	**97**	**506**	**3,027**
TOTAL LOW POWER	**1,674**	**9**	**60**	**1,605**
High Head/Low Power	**240**	**1**	**12**	**227**
Low Head/Low Power	**1,434**	**8**	**48**	**1,378**
Conventional Turbine	484	8	14	462
Unconventional Systems	316	0	23	293
Microhydro	634	0	11	623

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.



Total Hydropower Potential
5,766 MW

Figure A-32. Distribution of total hydropower potential in the Upper Mississippi Region (HUC 7).

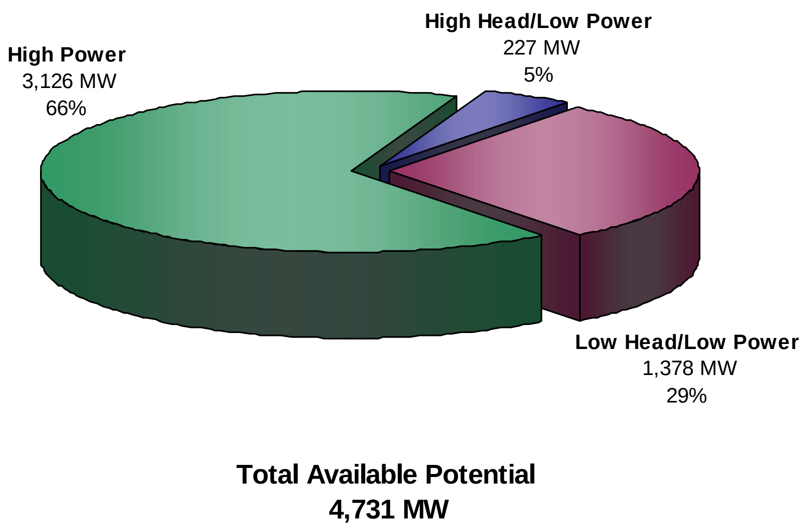


Figure A-33. Distribution of available hydropower potential in the Upper Mississippi Hydrologic Region (HUC 7).

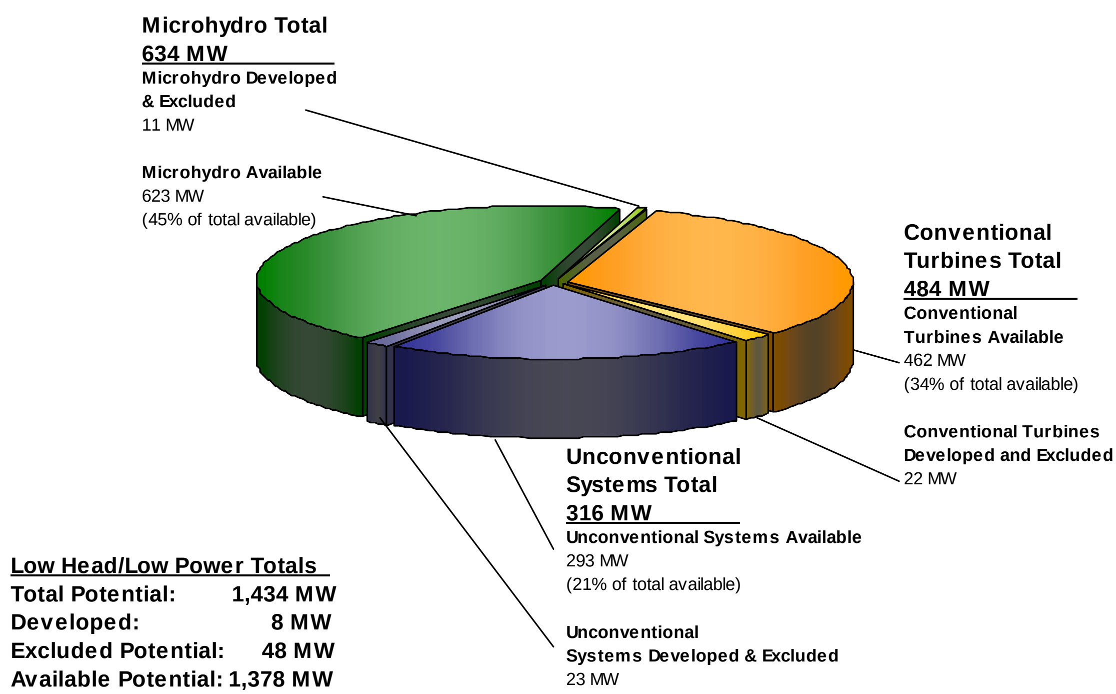


Figure A-34. Distribution of low head/low power hydropower potential in the Upper Mississippi Region (HUC 7) among three low head/low power hydropower technology classes.

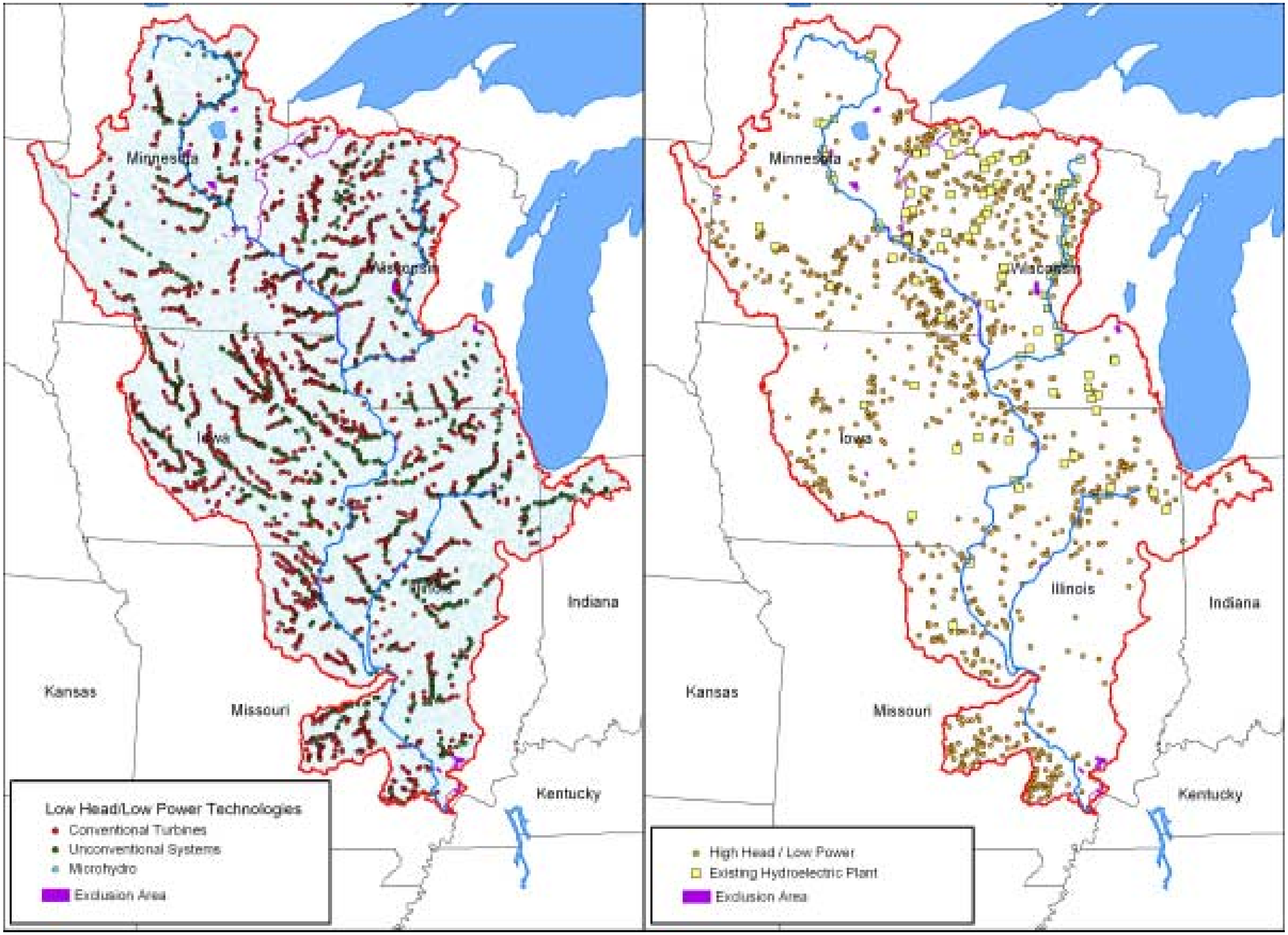


Figure A-35. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Upper Mississippi Region (HUC 7).

A.8 Lower Mississippi Region

A.8.1 Region Description

The topographic and hydrographic features of the Lower Mississippi Region are shown in Figure A-36. The region covers the Mississippi River downstream of its confluence with the Ohio River and the nearby watersheds. The region covers half of Mississippi and Arkansas, most of Louisiana, and parts of Kentucky, Tennessee, and Missouri that border the Mississippi River.

The region is dominated by the Mississippi River, its principal watercourse. The river is very large here, as it now carries the combined flows of the Ohio, upper Mississippi, Missouri, and numerous other rivers. The river meanders in a broad mature floodplain. In its natural state, the river channel periodically shifted within this floodplain. Oxbow lakes and marshes are the remnants of the abandoned river channels. In southern Louisiana, the river branches into several waterways to form the Mississippi River delta, where sediment loads from the river are deposited into the Gulf of Mexico. Like the upper Mississippi River, the lower reaches of the river contain channels and levees to permit navigation and prevent flooding of nearby lowlands.

Hills, plains, tributary river valleys, and pine woods occupy the uplands away from the main river floodplain. Wetlands composed of swamps and bayous dominate the delta areas of southern Louisiana and Mississippi. The climate in most of the region is warm and humid, with mild winters, abundant rainfall, and long growing seasons. Gulf coastal areas in particular are subject to tropical storms and hurricanes.

A.8.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

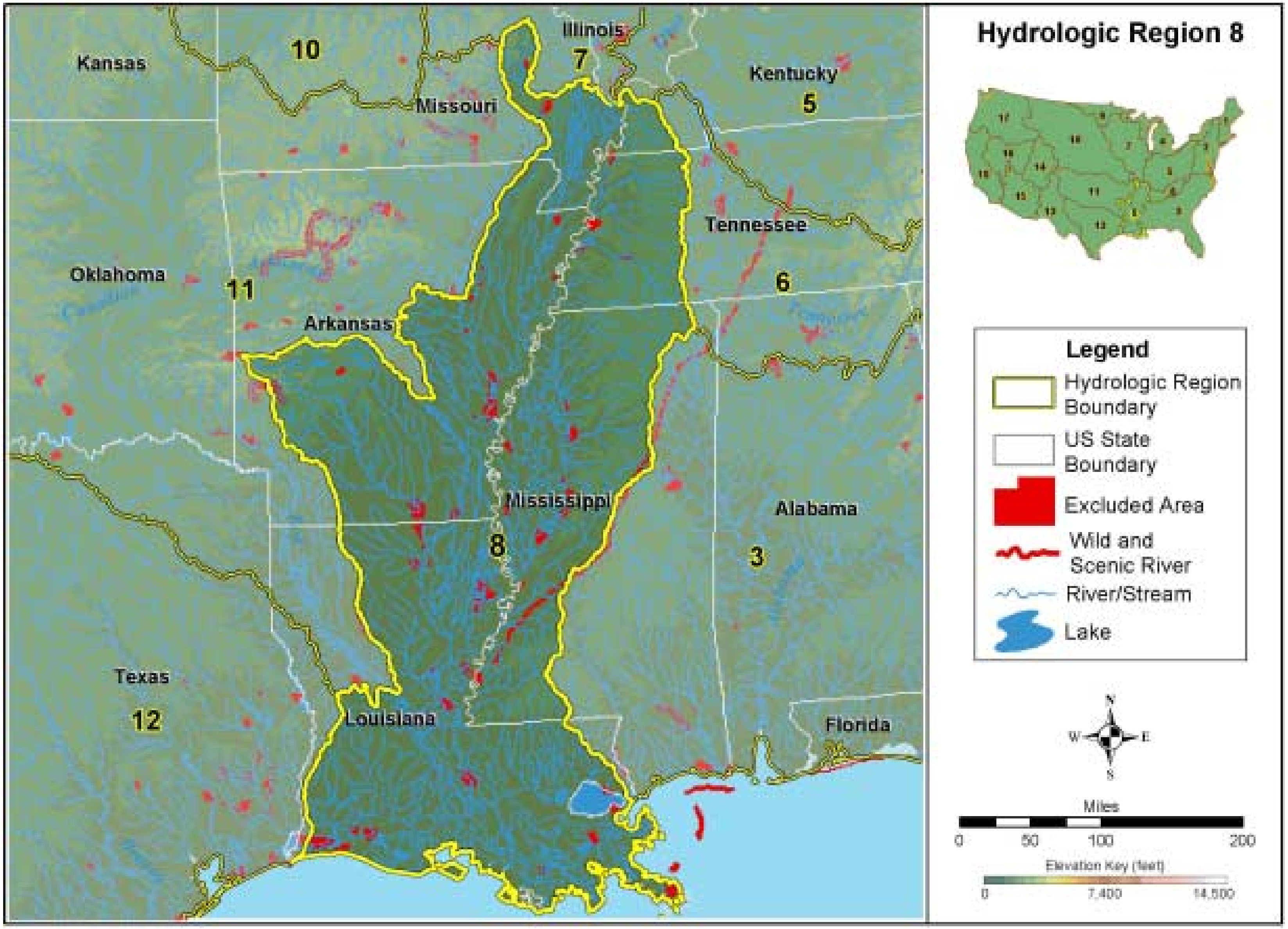


Figure A-36. Lower Mississippi Region (HUC 8).

Table A-8. Summary of results of hydropower resource assessment of the Lower Mississippi Region (HUC 8).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**12,418**	**136**	**835**	**11,447**
TOTAL HIGH POWER	**11,553**	**136**	**805**	**10,612**
High Head/High Power	**170**	**47**	**0**	**123**
Low Head/High Power	**11,383**	**89**	**805**	**10,489**
TOTAL LOW POWER	**865**	**0**	**30**	**835**
High Head/Low Power	**104**	**0**	**7**	**97**
Low Head/Low Power	**761**	**0**	**23**	**738**
Conventional Turbine	215	0	6	209
Unconventional Systems	222	0	9	213
Microhydro	324	0	8	316

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

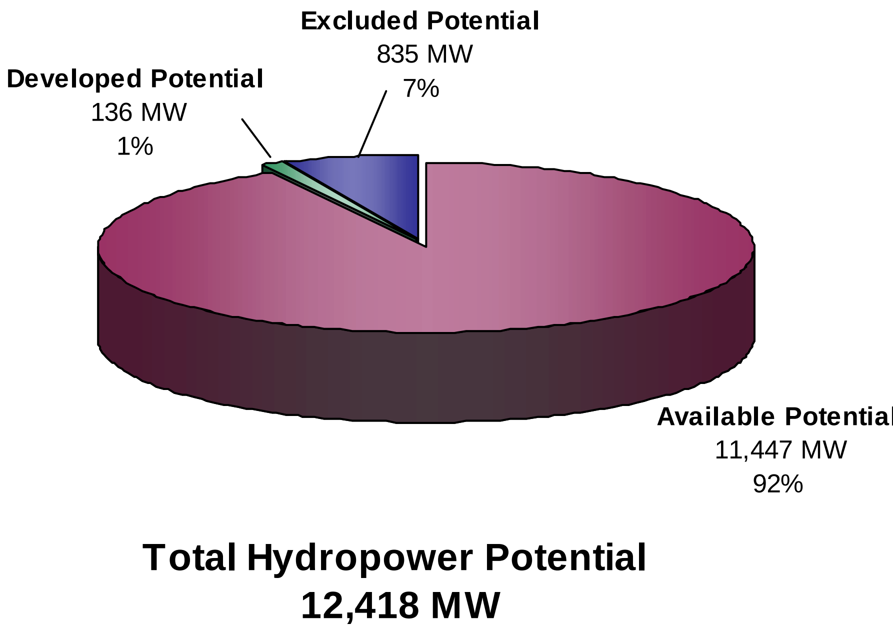


Figure A-37. Distribution of total hydropower potential in the Lower Mississippi Region (HUC 8).

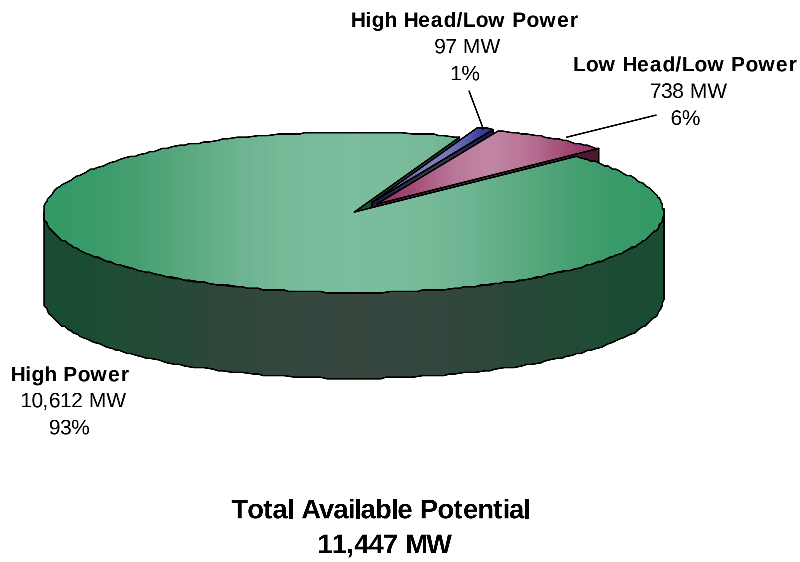


Figure A-38. Distribution of available hydropower potential in the Lower Mississippi Hydrologic Region (HUC 8).

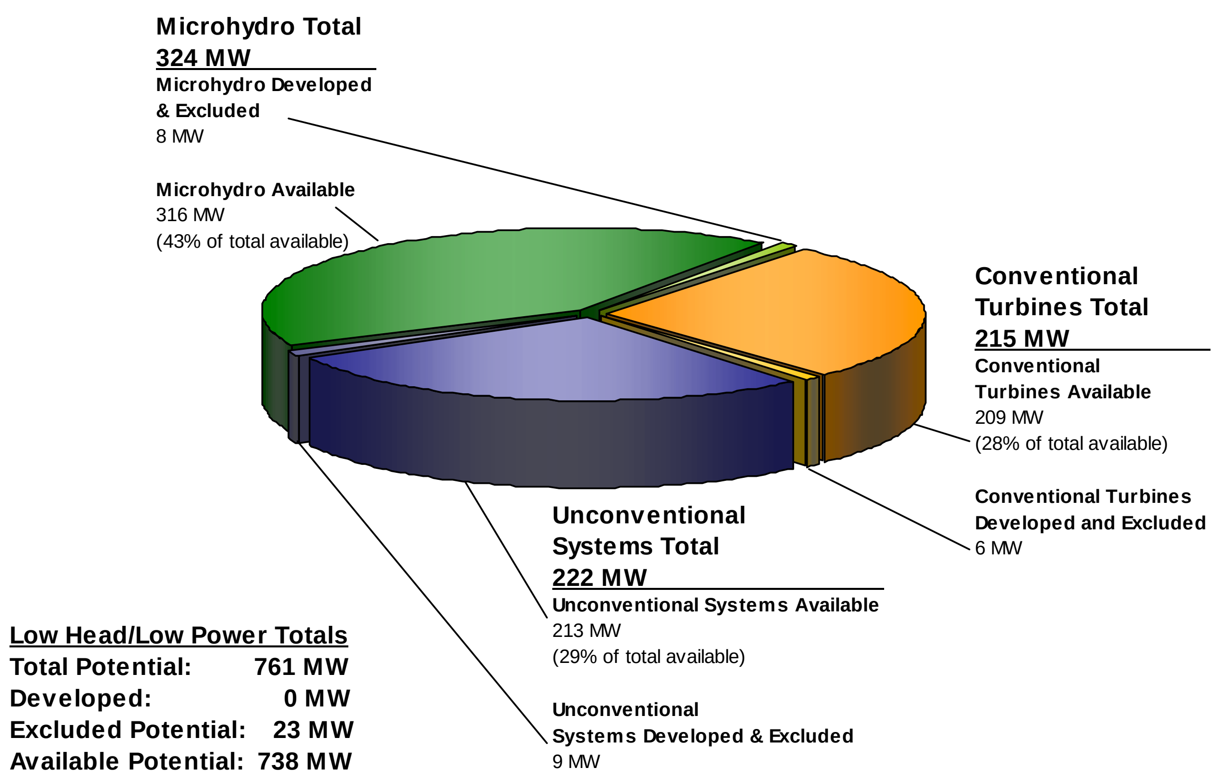


Figure A-39. Distribution of low head/low power hydropower potential in the Lower Mississippi Region (HUC 8) among three low head/low power hydropower technology classes.

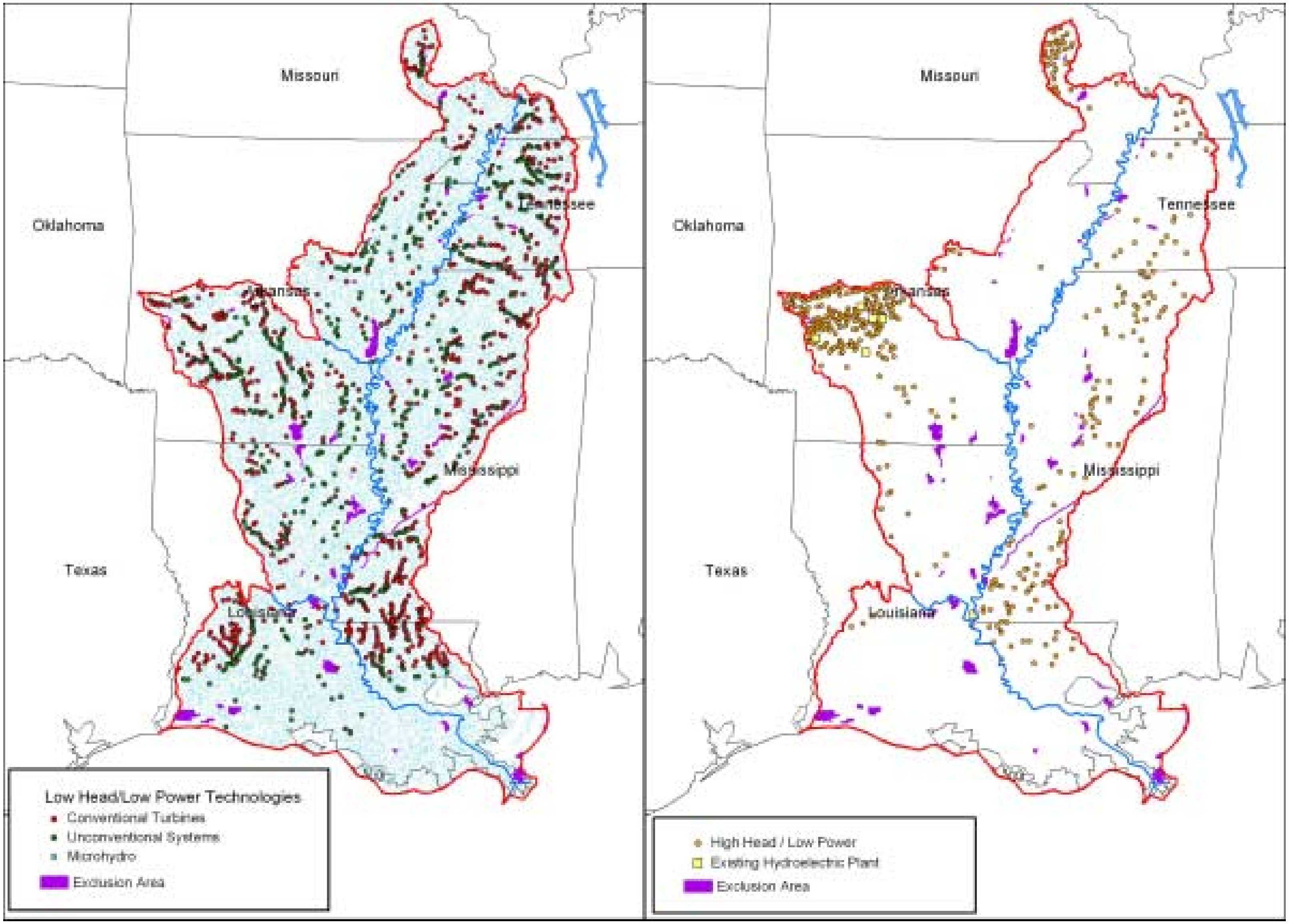


Figure A-40. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Upper Mississippi Region (HUC 8).

A.9 Souris Red-Rainy Region

A.9.1 Region Description

The topographic and hydrographic features of the Souris Red-Rainy Region are shown in Figure A-41. The region covers northern Minnesota, north and eastern North Dakota and a very small portion of South Dakota. Unlike most of the lower 48 states, the Red, Rainy, and Souris rivers flow northward into Canada. As a result, this region is the only watershed in the United States that drains into Hudson Bay. The Red River is sometimes called the “Red River of the North” to differentiate it from the Red River in the Arkansas White Red Region (HUC 11).

The region is composed of prairie, coniferous forests, lakes and wetlands. It is mostly flat, and poorly drained in many places. Most of Minnesota’s famed “10,000 lakes” are in this region, which contains many small and medium-sized towns, but no major cities. The climate is continental with long cold winters and a short summer growing season.

A.9.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

Souris Red-Rainy (HUC 9)

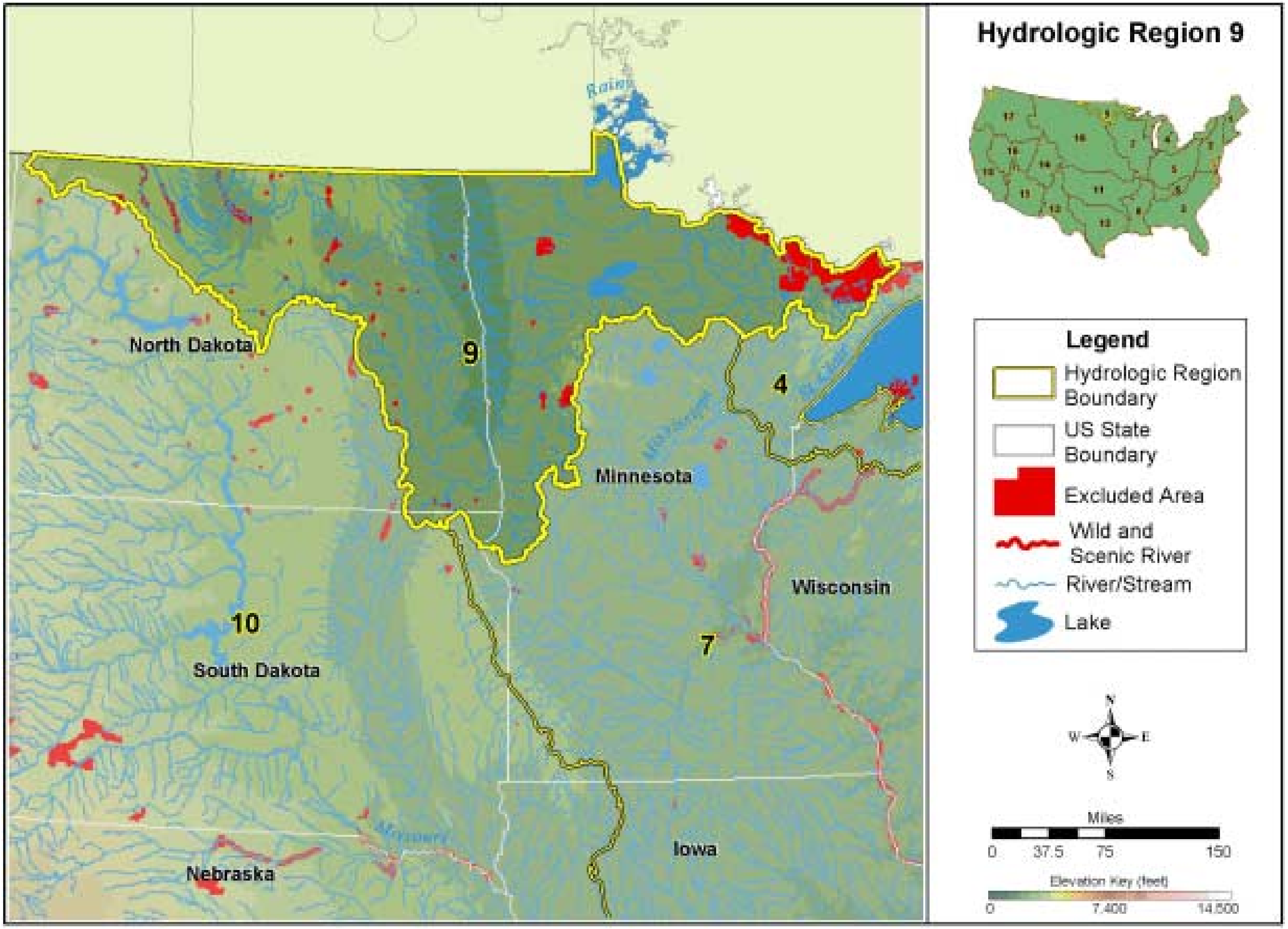


Figure A-41. Souris Red-Rainy Region (HUC 9).

Table A-9. Summary of results of hydropower resource assessment of the Souris Red-Rainy Region (HUC 9).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**431**	**13**	**101**	**317**
TOTAL HIGH POWER	**181**	**11**	**63**	**107**
High Head/High Power	**86**	**11**	**28**	**47**
Low Head/High Power	**95**	**0**	**35**	**60**
TOTAL LOW POWER	**250**	**2**	**38**	**210**
High Head/Low Power	**64**	**1**	**18**	**45**
Low Head/Low Power	**186**	**1**	**20**	**165**
Conventional Turbine	57	1	8	48
Unconventional Systems	26	0	4	22
Microhydro	103	0	8	95

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

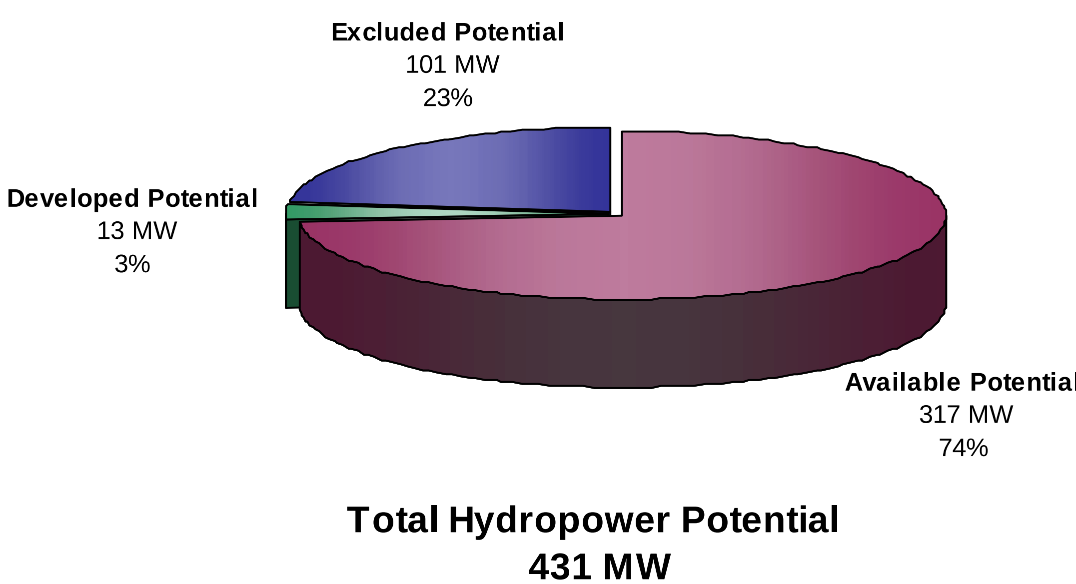


Figure A-42. Distribution of total hydropower potential in the Souris Red-Rainy Region (HUC 9).

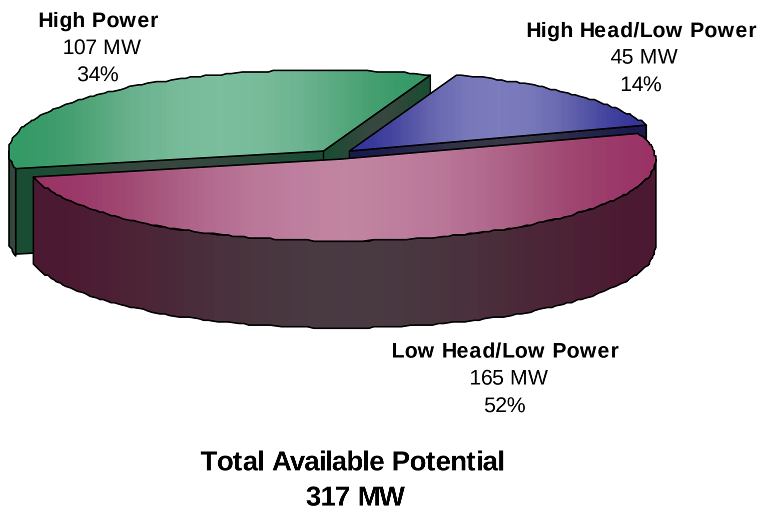


Figure A-43. Distribution of available hydropower potential in the Souris Red-Rainy Hydrologic Region (HUC 9).

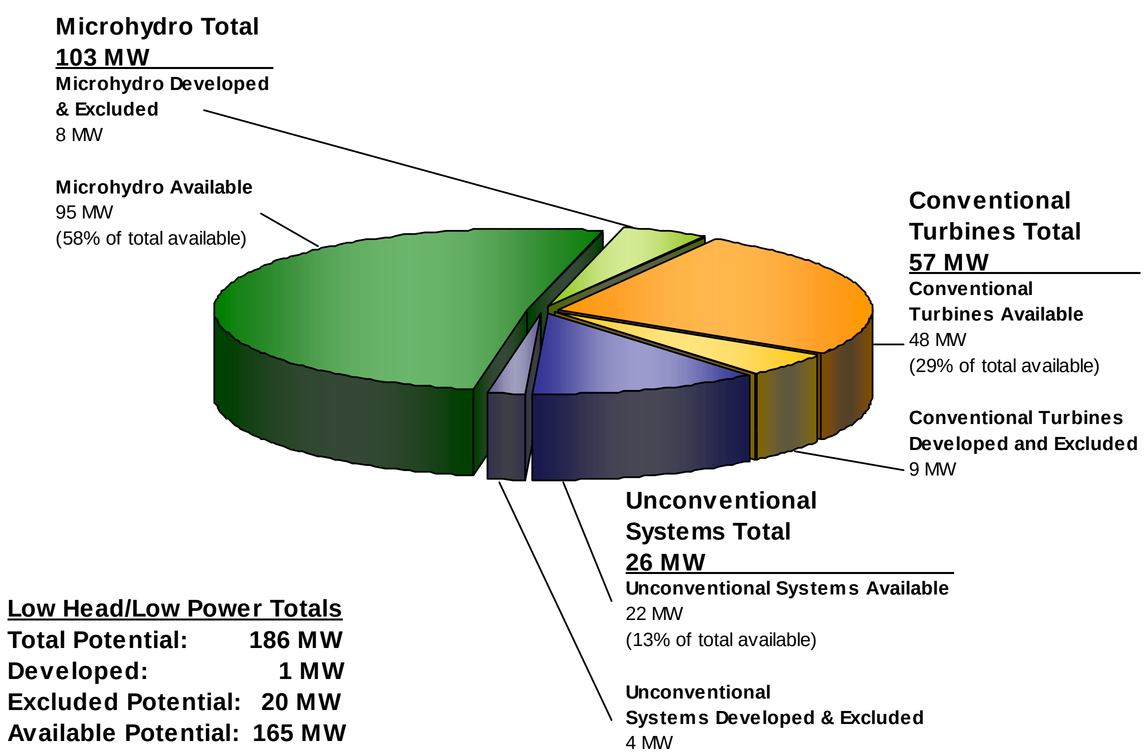


Figure A-44. Distribution of low head/low power hydropower potential in the Souris Red-Rainy Region (HUC 9) among three low head/low power hydropower technology classes.

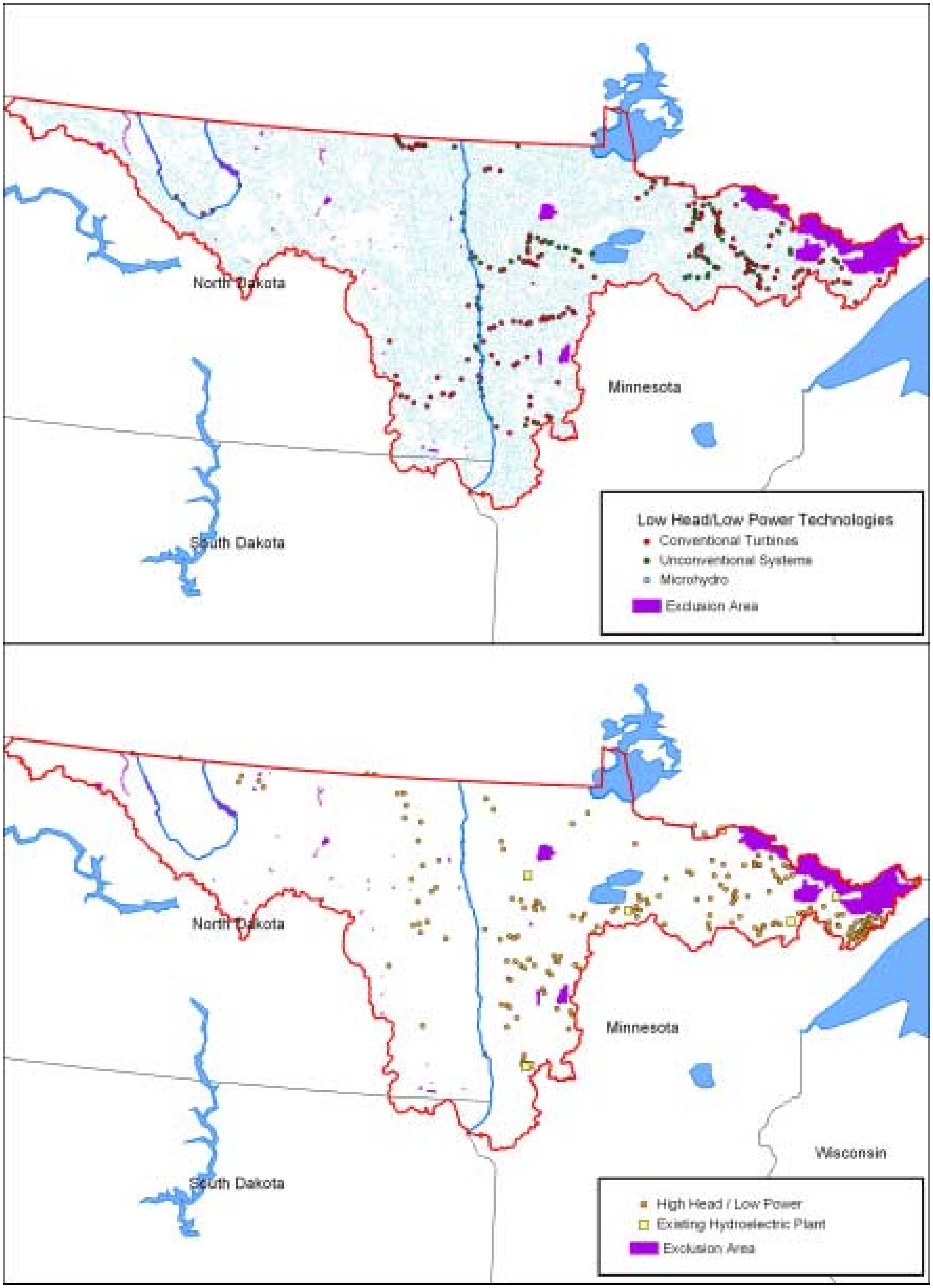


Figure A-45. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Souris Red-Rainy Region (HUC 9)

A.10 Missouri Region

A.10.1 Region Description

The topographic and hydrographic features of the Missouri Region are shown in Figure A-46. The region is by far the largest hydrologic region in the conterminous United States. It coincides with the entire Missouri River watershed up to the Canadian border and covers all of Nebraska, most of Montana, Wyoming, North Dakota, South Dakota, Missouri as well as parts of Colorado, Kansas, Iowa, and Minnesota.

The region extends from the margins of the Ozark Plateau in Missouri through the northern Great Plains to the summits of the Northern Rocky Mountains. The northern Great Plains, a vast, rolling prairie, comprises most of the region. In the south and east, the prairie is less than 1,500 feet above sea level, with elevations gradually but steadily increasing toward the west. For example, the high plains of western Nebraska and Colorado can exceed 5,000 feet in elevation. The region includes several entire mountain ranges including the Black Hills of South Dakota and the Big Horn Mountains of Wyoming. The entire eastern slope of the northern Rocky Mountains is also within this region, including parts of the Front Ranges of Colorado, Yellowstone National Park and Glacier National Park. In eastern Wyoming and southeastern Montana, flat arid plains alternate with disconnected mountain ranges.

The Missouri River is the principal river of this region. The Missouri River plus the lower Mississippi River constitutes the longest waterway in North America. Water from the eastern portions of Yellowstone and Glacier National Parks ultimately discharges into the Gulf of Mexico near New Orleans, Louisiana. Principal tributaries of the Missouri River include (from south to north) the Platte River, the Cheyenne River, the Little Missouri River, and the Yellowstone River. In western Montana, the Missouri River itself divides into three forks, named the Madison, Jefferson, and Gallatin by Lewis and Clark. The Missouri River and its tributaries have been dammed in many places for flood control, water supply and hydropower purposes. The largest of these include Ft. Peck Reservoir, Lake Sakakawea, Lake Ohae and Lake Francis Case, which create a series of elongated lakes (up to 200 mi. long) along the path of the Missouri River in Montana, North Dakota, and South Dakota.

The climate becomes gradually drier toward the west, with semi-arid steppe landscapes dominating the flat portions of eastern Wyoming and Montana. The climate in the northern plains and Rocky Mountains is severe with long, cold, winters and short summers. In the southeastern portions of the region, the climate is more temperate with long, hot summers.

A.10.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

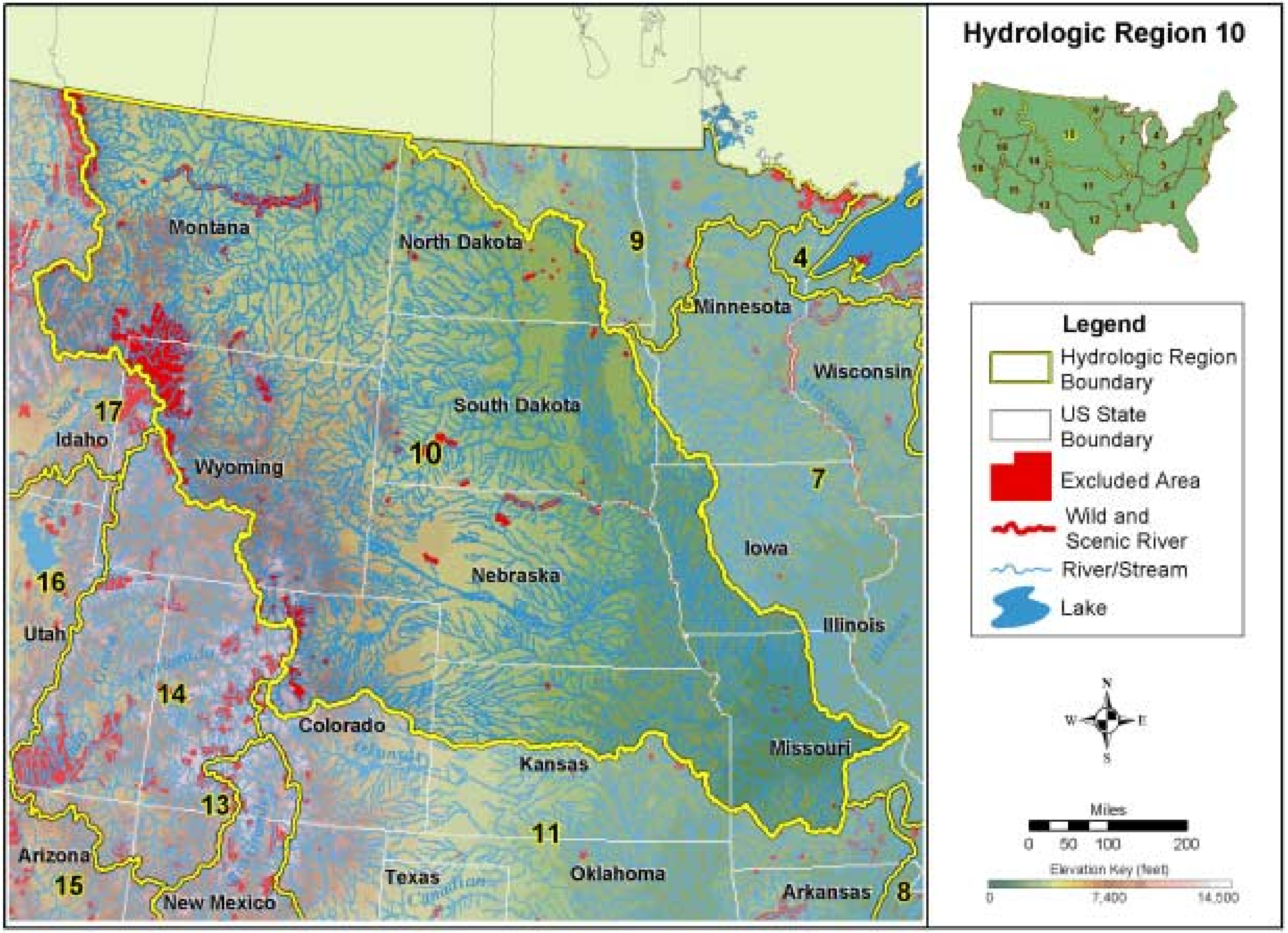


Figure A-46. Missouri Region (HUC 10).

Table A-10. Summary of results of hydropower resource assessment of the Missouri Region (HUC 10).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**15,823**	**1,796**	**4,622**	**9,405**
TOTAL HIGH POWER	**10,370**	**1,792**	**3,830**	**4,748**
High Head/High Power	**7,538**	**1,784**	**3,533**	**2,221**
Low Head/High Power	**2,832**	**8**	**297**	**2,527**
TOTAL LOW POWER	**5,453**	**4**	**792**	**4,657**
High Head/Low Power	**2,512**	**4**	**658**	**1,850**
Low Head/Low Power	**2,941**	**0**	**134**	**2,807**
Conventional Turbine	1,157	0	66	1,091
Unconventional Systems	370	0	30	340
Microhydro	1,414	0	38	1,376

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

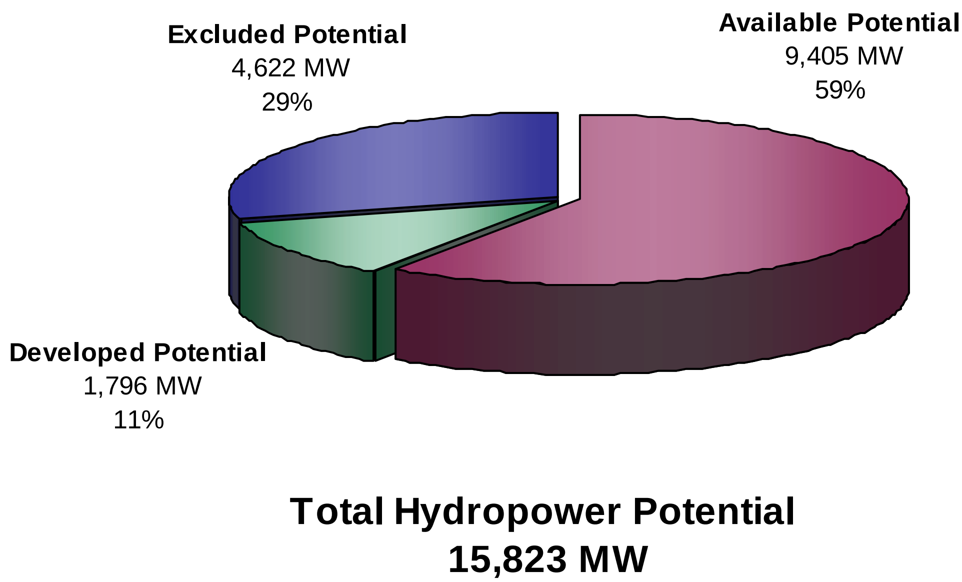


Figure A-47. Distribution of total hydropower potential in the Missouri Region (HUC 10).

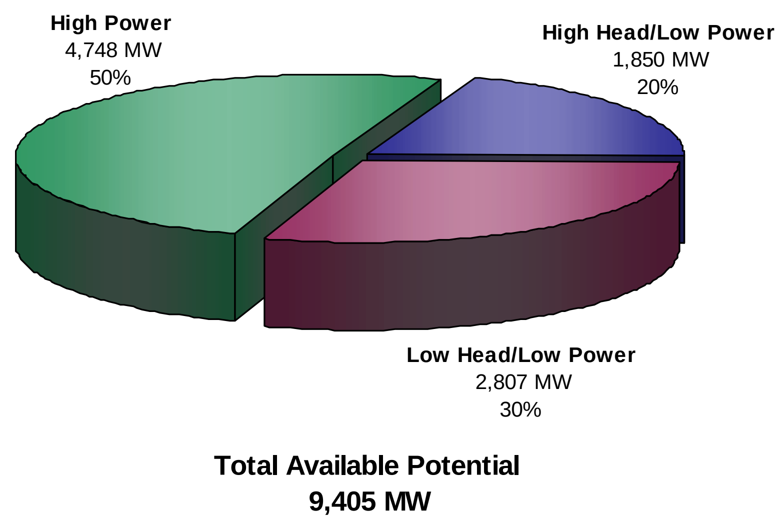


Figure A-48. Distribution of available hydropower potential in the Missouri Hydrologic Region (HUC 10).

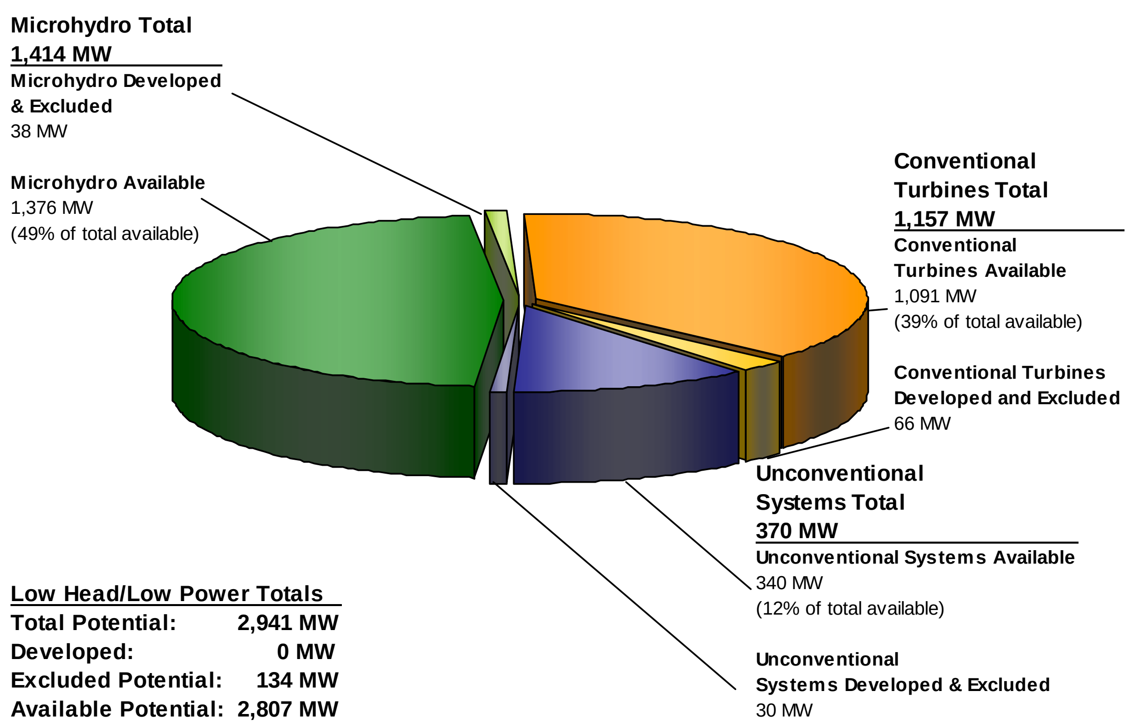


Figure A-49. Distribution of low head/low power hydropower potential in the Missouri Region (HUC 10) among three low head/low power hydropower technology classes.

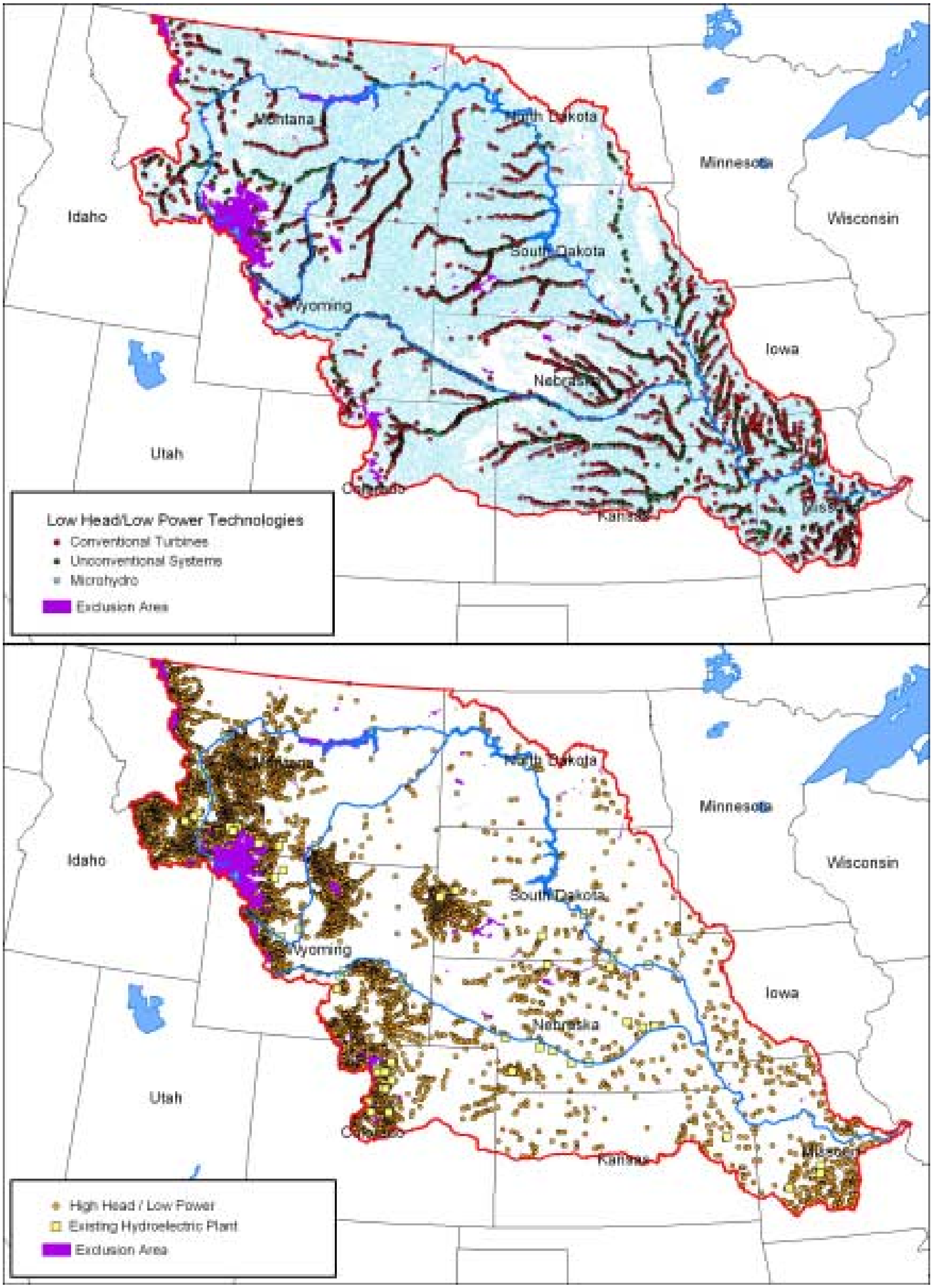


Figure A-50. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Missouri Region (HUC 10).

A.11 Arkansas-White-Red Region

A.11.1 Region Description

The topographic and hydrographic features of the Arkansas-White-Red (AWR) Region are shown in Figure A-51. The region is composed of three watersheds: the Arkansas River and its major tributary, the Canadian River; the Red River; and the White River. The AWR Region covers the entire State of Oklahoma as well as portions of seven nearby states (Texas, New Mexico, Colorado, Kansas, Missouri, Arkansas, and Louisiana).

The topography over much of the AWR Region is relatively flat with some notable exceptions. Most of the region falls within the southern Great Plains and is characterized by either flat plains or rolling hills broken by stream floodplains. Higher relief is found in the Ozark Plateau and Ouachita Mountains in the eastern portion of the region where the states of Arkansas, Oklahoma, and Missouri meet. The westernmost part of the region extends all the way to the headwaters of the Arkansas and Canadian Rivers. The upper portions of these watersheds border the continental divide in Colorado and New Mexico. This part of the AWR Region contains topography characteristic of the southern Rocky Mountains: high plateaus and mountains incised by steep canyons and separated by deep valleys.

In the southern half of the AWR Region, the climate is warm, with hot summers and mild winters. The northern half of the region experiences great seasonal extremes of weather, subject to cold winters and hot summers. Colliding air masses from the north and south create sudden temperature changes, blizzards, severe thunderstorms, and tornadoes. The eastern half of the region is humid, but becomes increasingly dry toward the west.

A.11.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

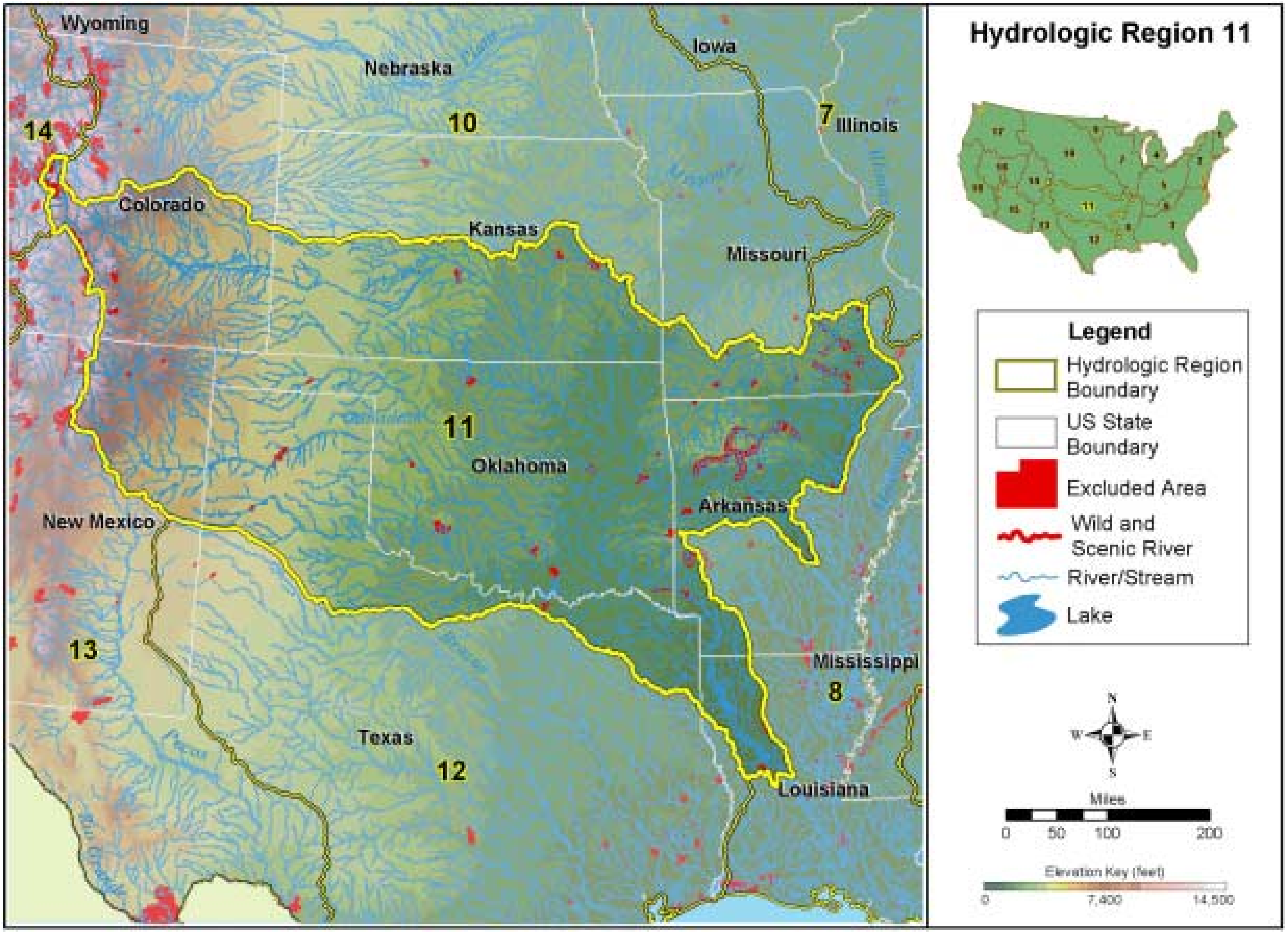


Figure A-51. Arkansas-White-Red Region (HUC 11).

Table A-11. Summary of results of hydropower resource assessment of Arkansas-White-Red Region (HUC 11).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**5,053**	**696**	**329**	**4,028**
TOTAL HIGH POWER	**2,364**	**695**	**136**	**1,533**
High Head/High Power	**871**	**598**	**86**	**187**
Low Head/High Power	**1,493**	**97**	**50**	**1,346**
TOTAL LOW POWER	**2,689**	**1**	**193**	**2,495**
High Head/Low Power	**802**	**1**	**105**	**696**
Low Head/Low Power	**1,887**	**0**	**88**	**1,799**
Conventional Turbine	762	0	41	721
Unconventional Systems	351	0	22	329
Microhydro	774	0	25	749

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

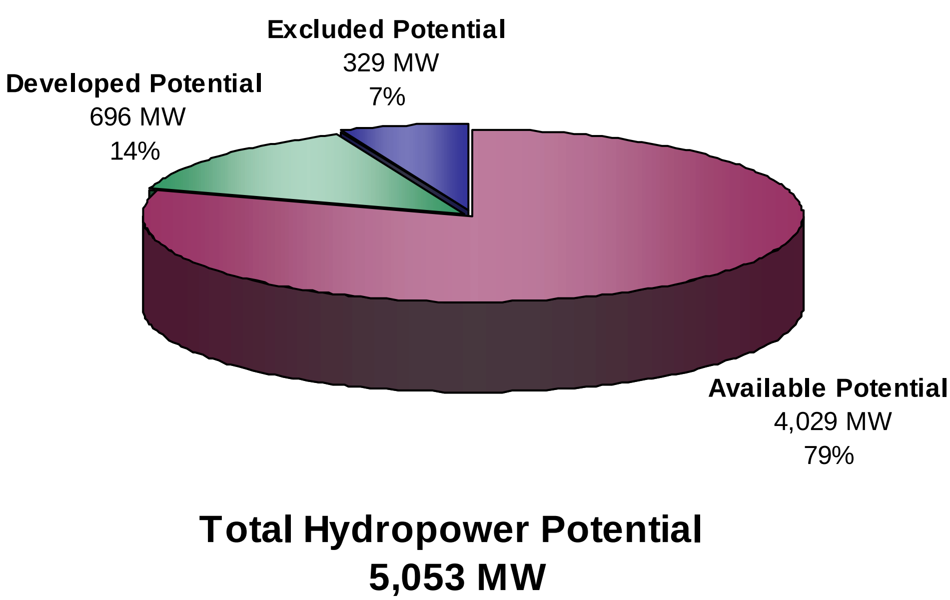


Figure A-52. Distribution of total hydropower potential in the Arkansas-White-Red Region (HUC 11).

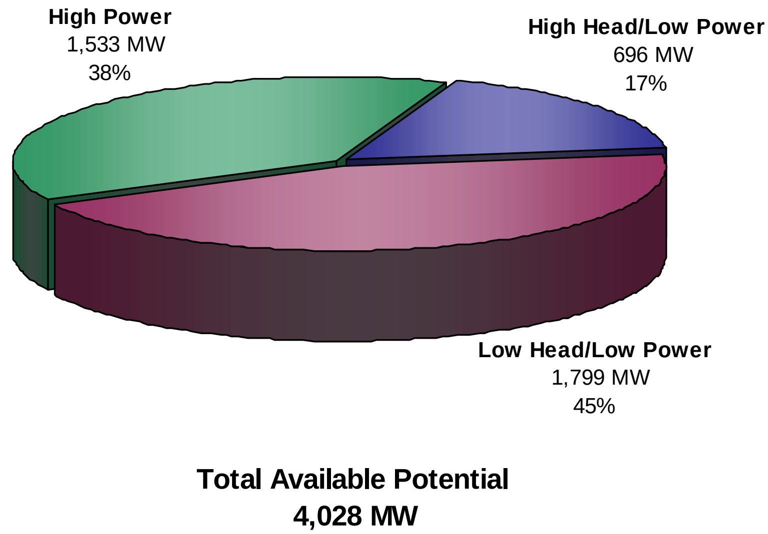


Figure A-53. Distribution of available hydropower potential in the Arkansas-White-Red Hydrologic Region (HUC 11).

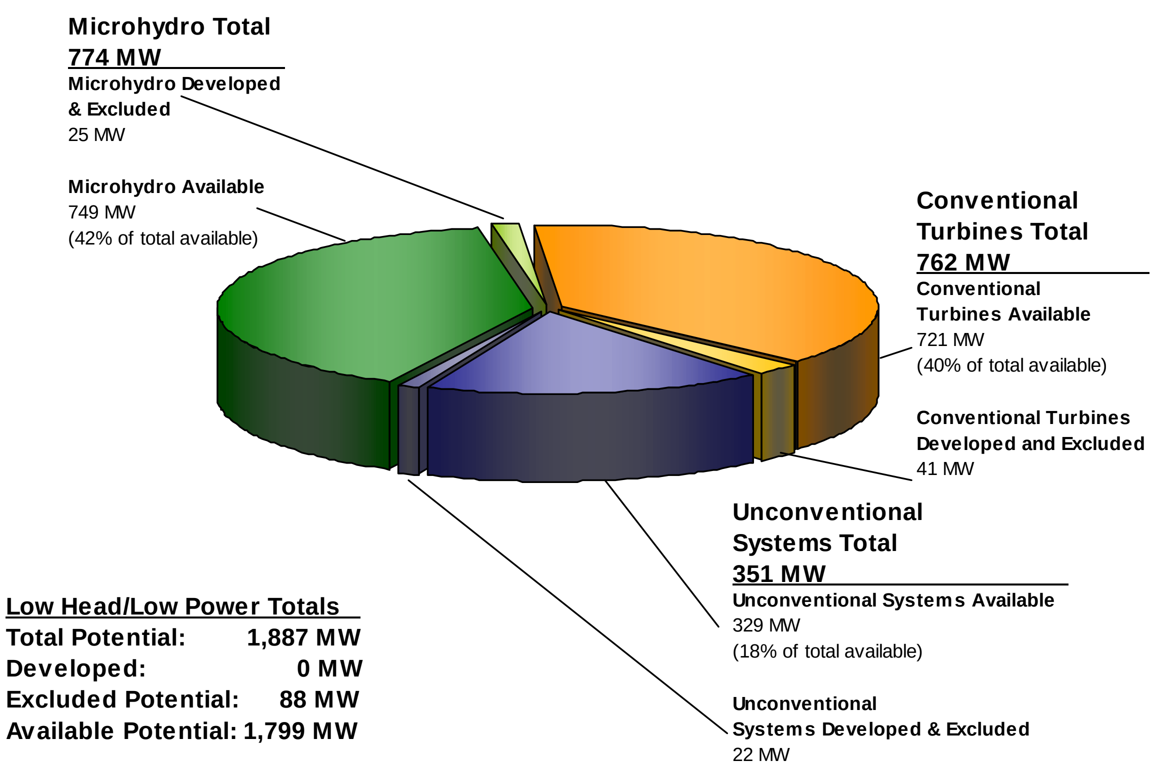


Figure A-54. Distribution of low head/low power hydropower potential in the Arkansas-White-Red Region (HUC 11) among three low head/low power hydropower technology classes.

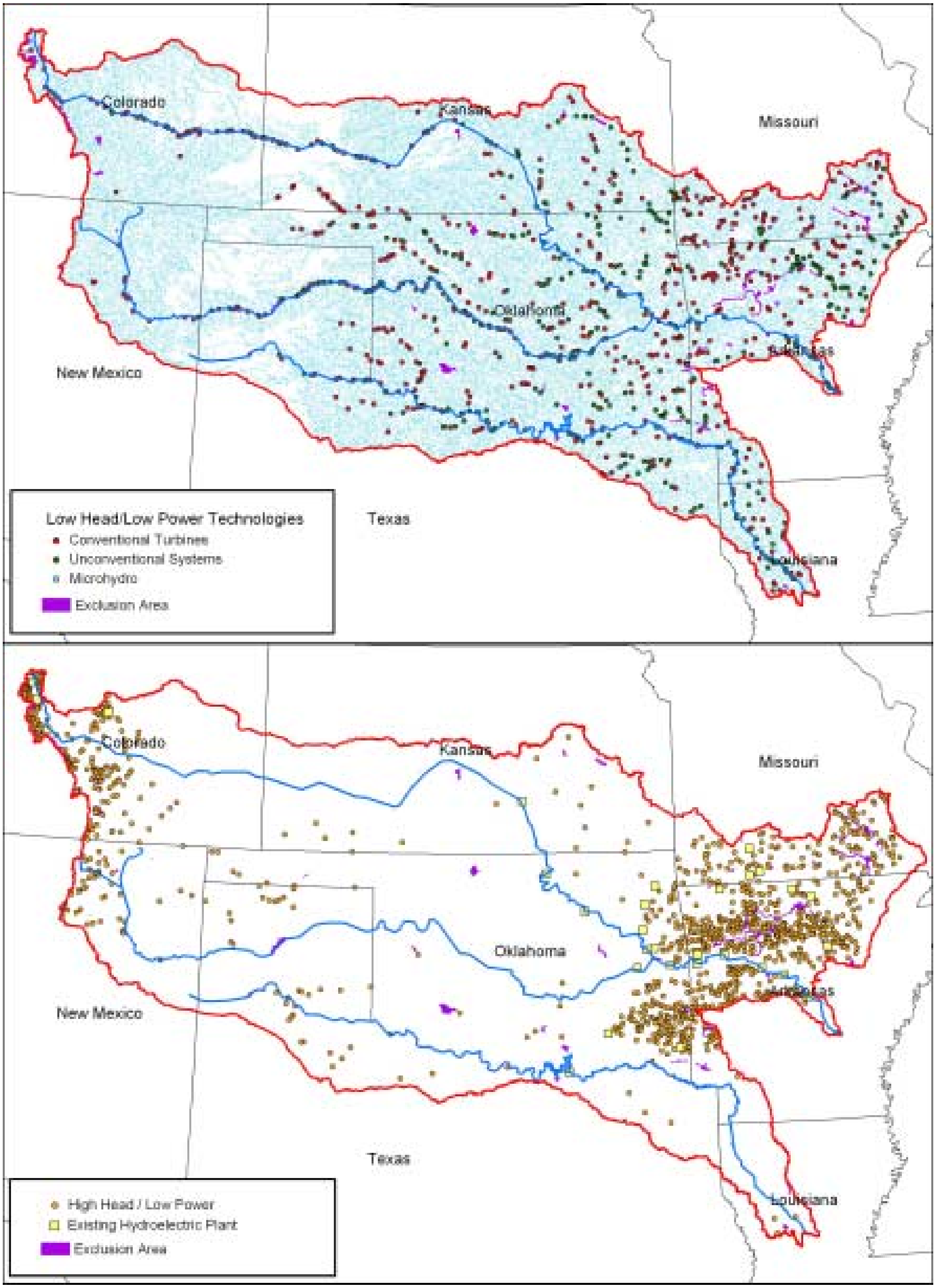


Figure A-55. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Arkansas-White-Red Region (HUC 11).

A.12 Texas-Gulf Region

A.12.1 Region Description

The topographic and hydrographic features of the Texas-Gulf Region are shown in Figure A-56. The region coincides with most of the State of Texas, except for the Red River Valley, the Rio Grande Valley, the panhandle, and West Texas. Small portions of western Louisiana and eastern New Mexico are also included in this region. Landscapes vary from swamps and bayous along the Gulf Coast near Louisiana, to pine and cypress forests and lush grasslands in the remainder of East Texas. The eastern portion consists of flat, fertile plains with ample rainfall. Toward the west, the land passes through the Texas Hill Country before rising stepwise to the tablelands of the Edwards Plateau (750 to 2,000 feet in elevation), and finally to the Llano Estacado, a high, dry, desolate, windswept plain along the Texas-New Mexico state line.

Several moderate-sized rivers drain the region, emptying directly into the Gulf of Mexico. These include the Brazos, Trinity, and Sabine Rivers. Hydropower projects have been built on all these rivers.

The climate becomes increasing arid toward the west. The southern portions of the region are warm enough to support citrus orchards.

A.12.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

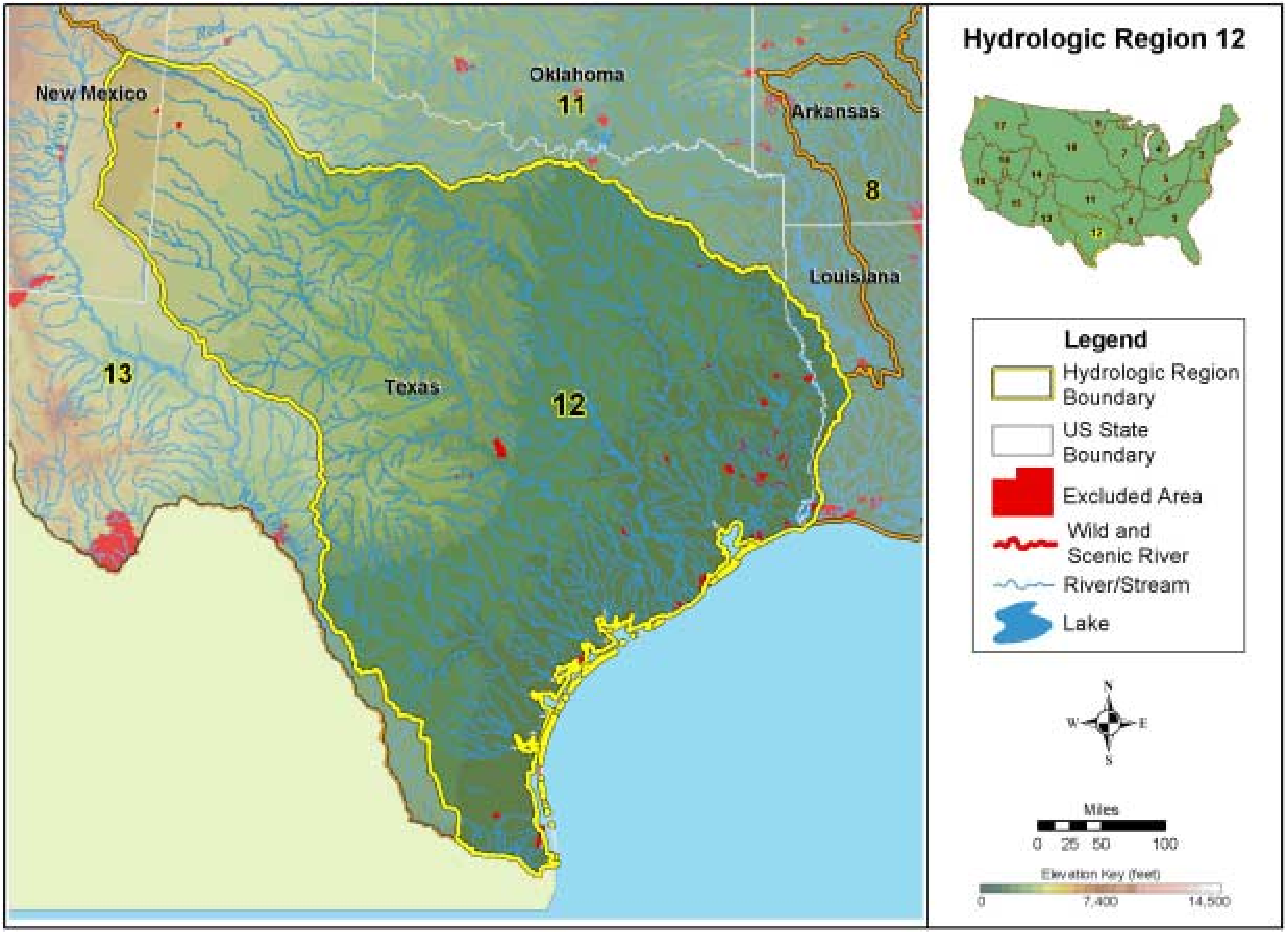


Figure A-56. Texas-Gulf Region (HUC 12).

Table A-12. Summary of results of hydropower resource assessment of the Texas-Gulf Region (HUC 12).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,811**	**127**	**61**	**1,623**
TOTAL HIGH POWER	**523**	**127**	**39**	**357**
High Head/High Power	**209**	**117**	**2**	**90**
Low Head/High Power	**314**	**10**	**37**	**267**
TOTAL LOW POWER	**1,288**	**0**	**22**	**1,266**
High Head/Low Power	**196**	**0**	**2**	**194**
Low Head/Low Power	**1,092**	**0**	**20**	**1,072**
Conventional Turbine	330	0	5	325
Unconventional Systems	188	0	9	179
Microhydro	574	0	6	568

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

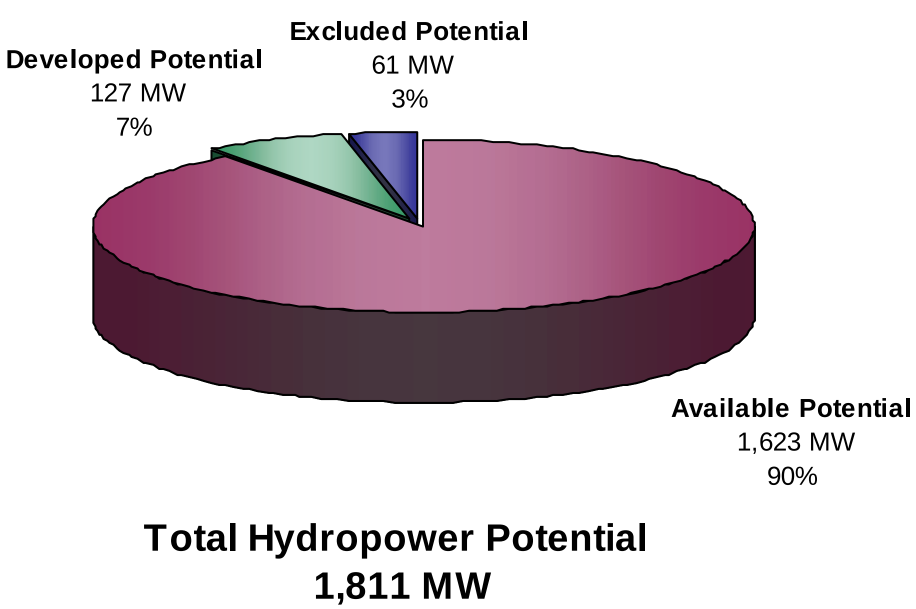


Figure A-57. Distribution of total hydropower potential in the Texas-Gulf Region (HUC 12).

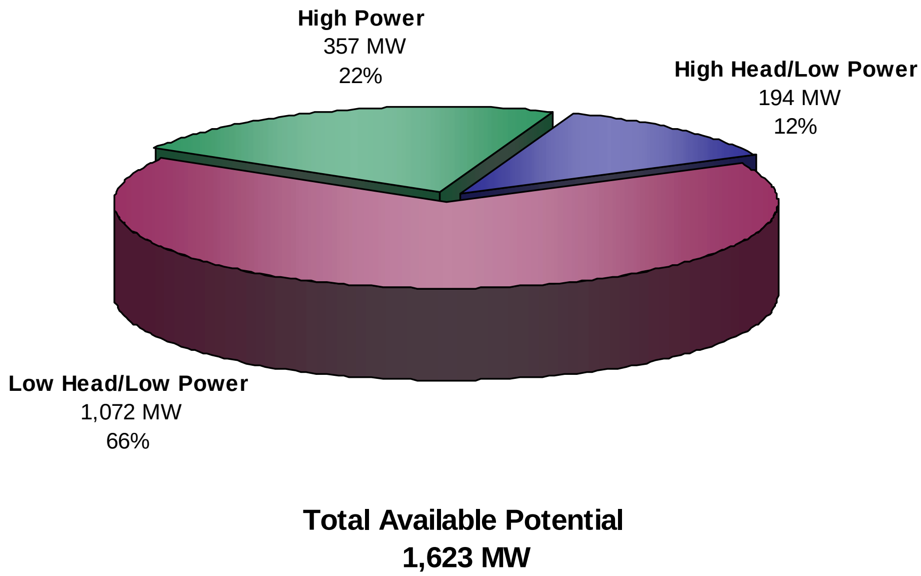


Figure A-58. Distribution of available hydropower potential in the Texas-Gulf Hydrologic Region (HUC 12).

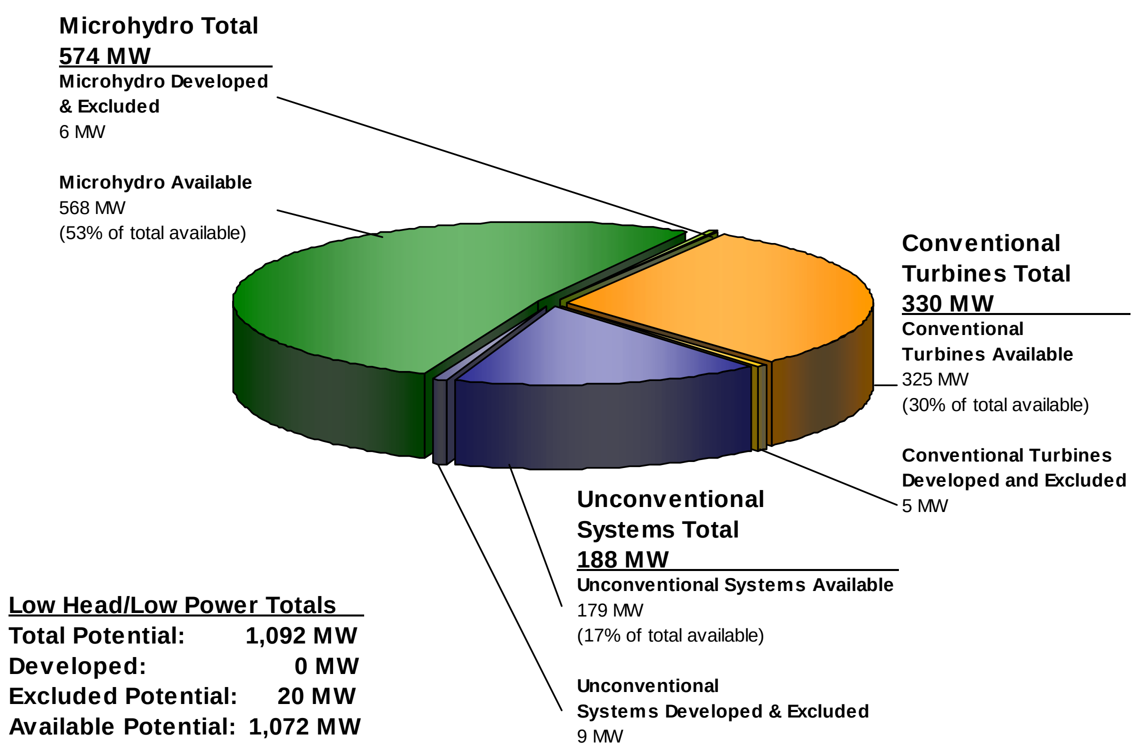


Figure A-59. Distribution of low head/low power hydropower potential in the Texas-Gulf Region (HUC 12) among three low head/low power hydropower technology classes.

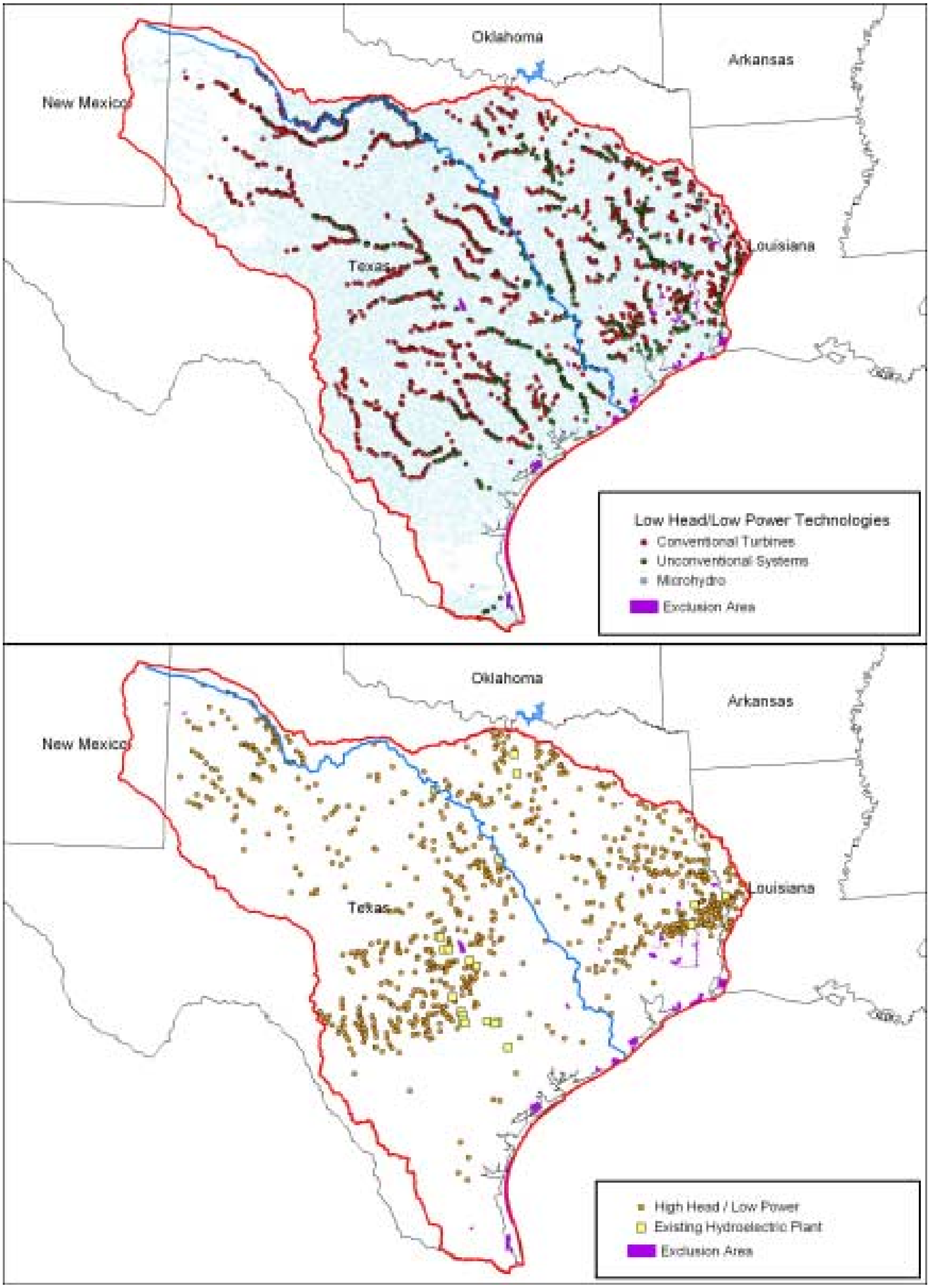


Figure A-60. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Texas-Gulf Region (HUC 12).

A.13 Rio Grande Region

A.13.1 Region Description

The topographic and hydrographic features of the Rio Grande Region are shown in Figure A-61. The region includes the entire Rio Grande watershed north of the United States-Mexican border. It extends from the Gulf of Mexico to the Continental Divide, covering most of New Mexico, part of south-central Colorado, much of west Texas, as well as a narrow strip of Texas along the Mexican border.

The headwaters of the Rio Grande River are found in the San Juan Mountains, a high mountain range in southern Colorado. The Rio Grande flows southward into New Mexico, where it bisects the state in a north-south trending tectonic rift valley. The Pecos River, the principal tributary of the Rio Grande, originates in northern New Mexico near Santa Fe to join the Rio Grande in west Texas. The Rio Grande skirts the mountains of west Texas before entering the Gulf Plain, a broad coastal plain bordering the Gulf of Mexico.

The climate in Colorado, New Mexico, and west Texas is generally dry, with arid to semi-arid brushland and steppe dominating. More precipitation falls in the high mountains of northern New Mexico and southern Colorado, where elevations can exceed 13,000 feet. The climate becomes more humid toward the Gulf Coast.

A.13.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

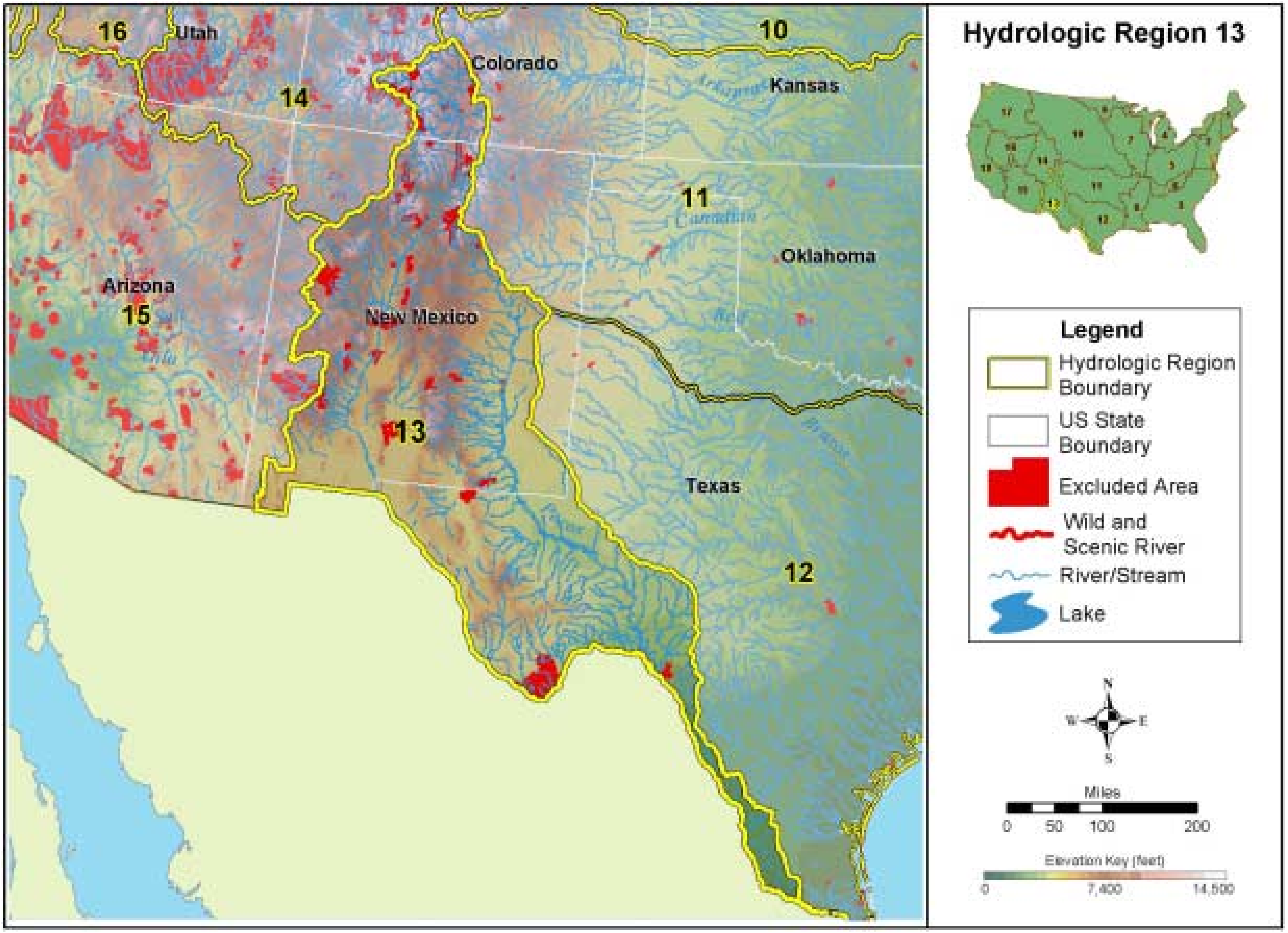


Figure A-61. Rio Grande Region (HUC 13).

Table A-13. Summary of results of hydropower resource assessment of the Rio Grande Region (HUC 13).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**2,122**	**50**	**602**	**1,470**
TOTAL HIGH POWER	**811**	**50**	**385**	**376**
High Head/High Power	**721**	**50**	**354**	**317**
Low Head/High Power	**90**	**0**	**31**	**59**
TOTAL LOW POWER	**1,311**	**0**	**217**	**1,094**
High Head/Low Power	**697**	**0**	**167**	**530**
Low Head/Low Power	**614**	**0**	**50**	**564**
Conventional Turbine	177	0	18	159
Unconventional Systems	87	0	9	78
Microhydro	350	0	23	327

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

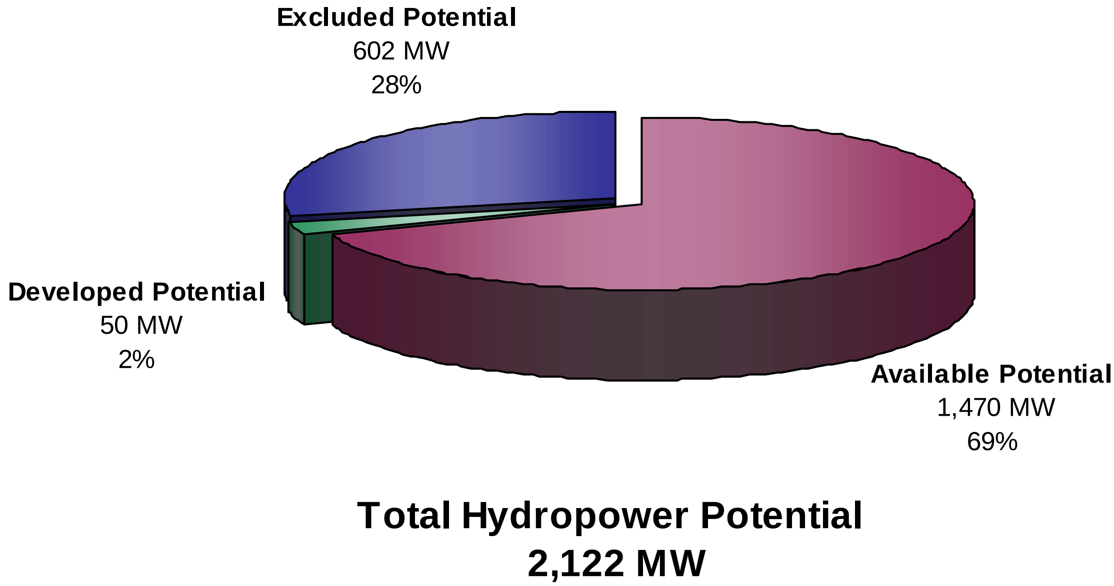


Figure A-62. Distribution of total hydropower potential in the Rio Grande Region (HUC 13).

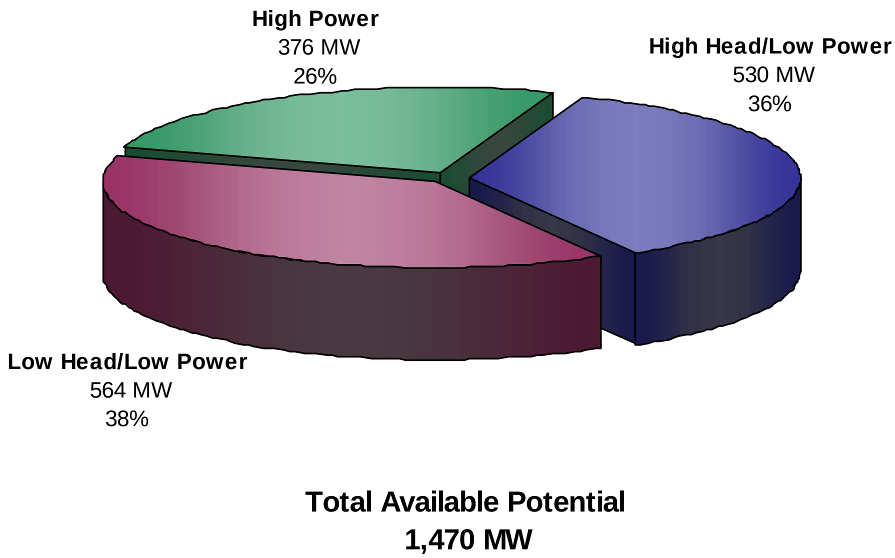


Figure A-63. Distribution of available hydropower potential in the Rio Grande Hydrologic Region (HUC 13).

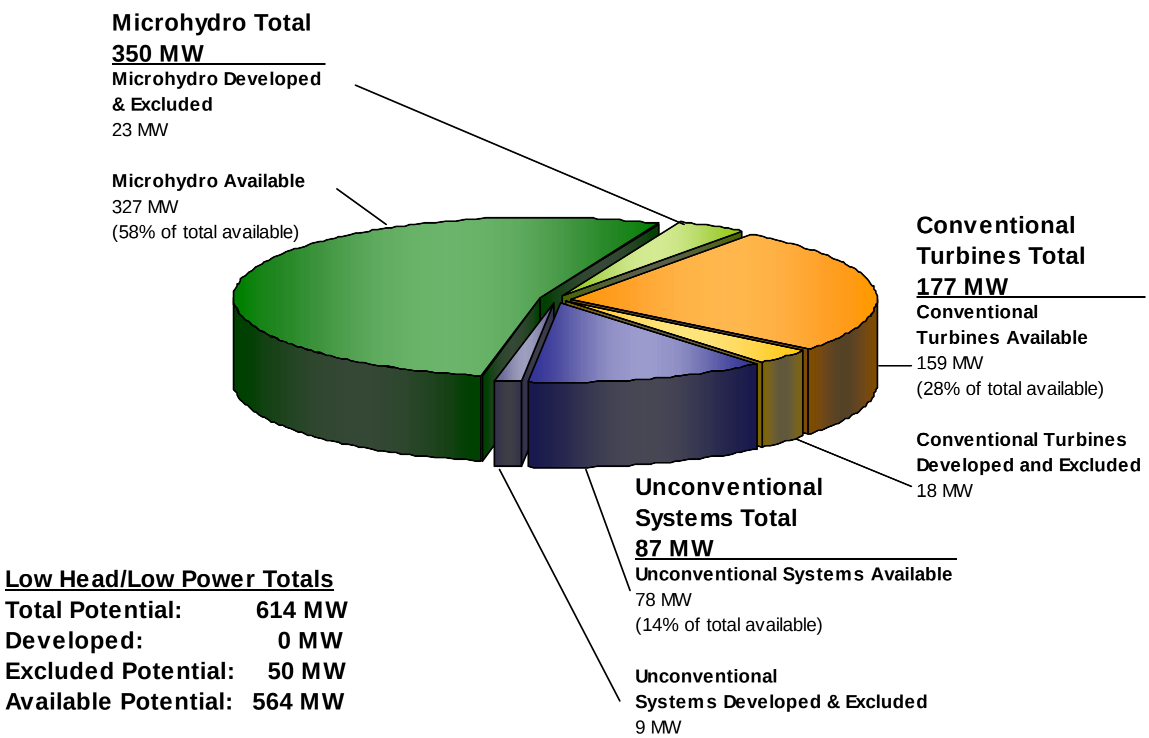


Figure A-64. Distribution of low head/low power hydropower potential in the Rio Grande Region (HUC 13) among three low head/low power hydropower technology classes.

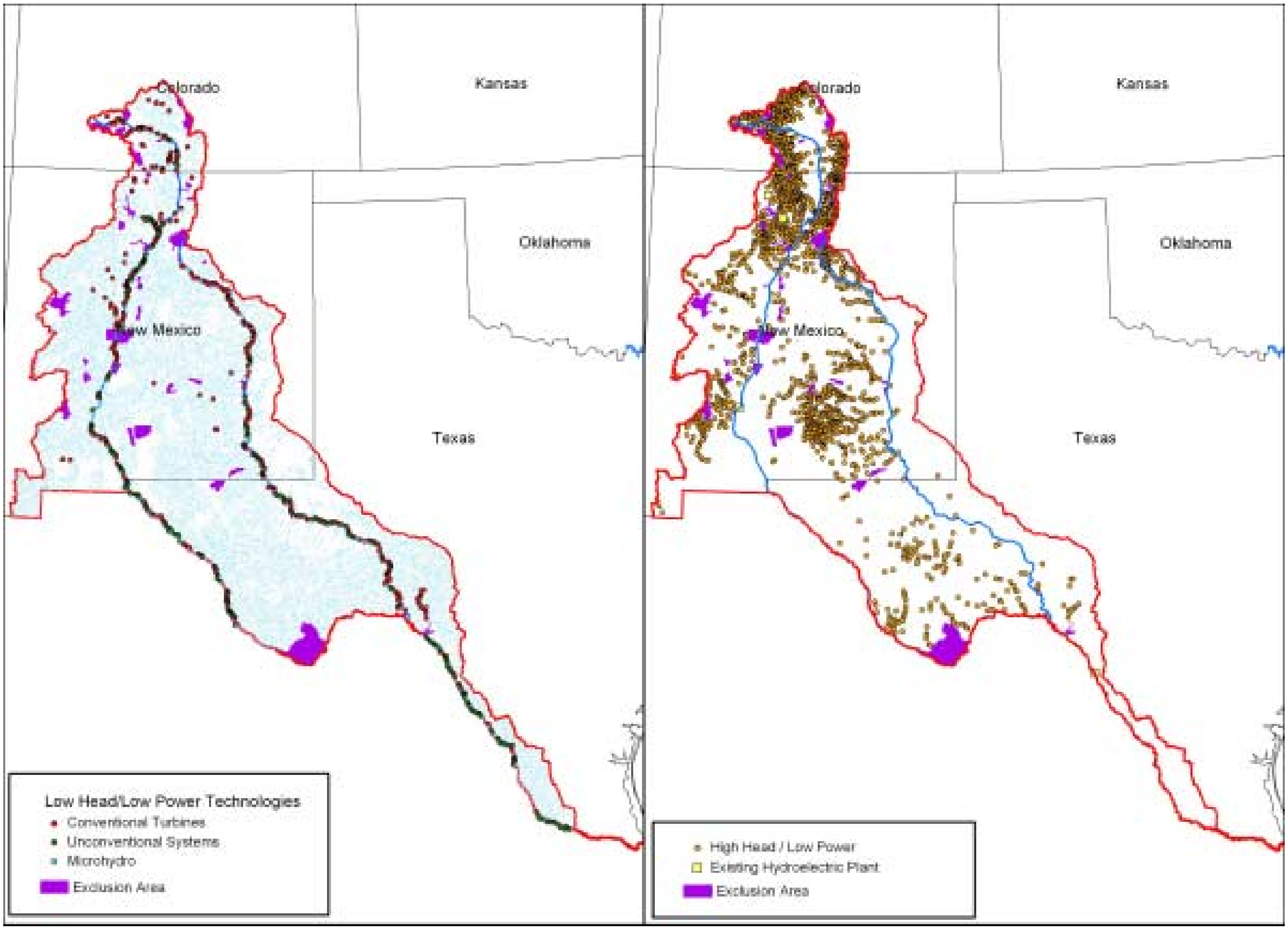


Figure A-65. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Rio Grande Region (HUC 13).

A.14 Upper Colorado Region

A.14.1 Region Description

The topographic and hydrographic features of the Upper Colorado Region are shown in Figure A-66. The region occupies the eastern half of Utah, the western half of Colorado, the southwestern quarter of Wyoming, and portions of northern Arizona and New Mexico. The Colorado Plateau covers the southwestern portion of this region while the Rocky Mountains occupy the eastern and northern portions. The Colorado Plateau, approximately 3,000 to 7,000 feet in elevation, consists of extensive layers of sedimentary rocks. Wind and water erosion of these brightly colored horizontal rock layers have formed a series of buttes, mesas, and cliffs renown for their austere scenic beauty.

Two major rivers, the Colorado River and its principal tributary, the Green River, drain the Upper Colorado Region. Other tributaries include the Gunnison River in Colorado and the San Juan River, which flows through the Four Corners area. In many areas the rivers have carved deep step-like canyons into the plateau. Some canyons are over 3,000 feet deep.

Two major canyons have been dammed for hydropower projects. Glen Canyon Dam, on the Colorado River on the Arizona-Utah border, has created Lake Powell, which extends some 200 miles into southern Utah. Flaming Gorge Reservoir, on the middle reach of the Green River, straddles the Utah-Wyoming state line. Other parts of the region, including portions of the Colorado and Green Rivers, are preserved in national parks, monuments, and recreation areas, where future hydropower development is unlikely. Indian reservations occupy significant portions of the Upper Colorado Region, including the Navajo and Hopi reservations in the Four Corners area and the Uinta-Ouray Reservation in Eastern Utah.

In general, the Upper Colorado Region is arid and sparsely populated, with predominantly desert and steppe environments. East and north of the Colorado Plateau, flat rock layers give way to complexly folded and deformed rocks of the Rocky Mountains. Elevations of 8,000 feet or higher are common, with many peaks in Colorado exceeding 14,000 feet. Precipitation levels are higher in the mountainous portions of the region due to orographic effects. Vegetation here includes coniferous forests and high-mountain meadows. These relatively wetter mountain areas give rise to the headwaters of both the Colorado and Green Rivers.

A.14.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

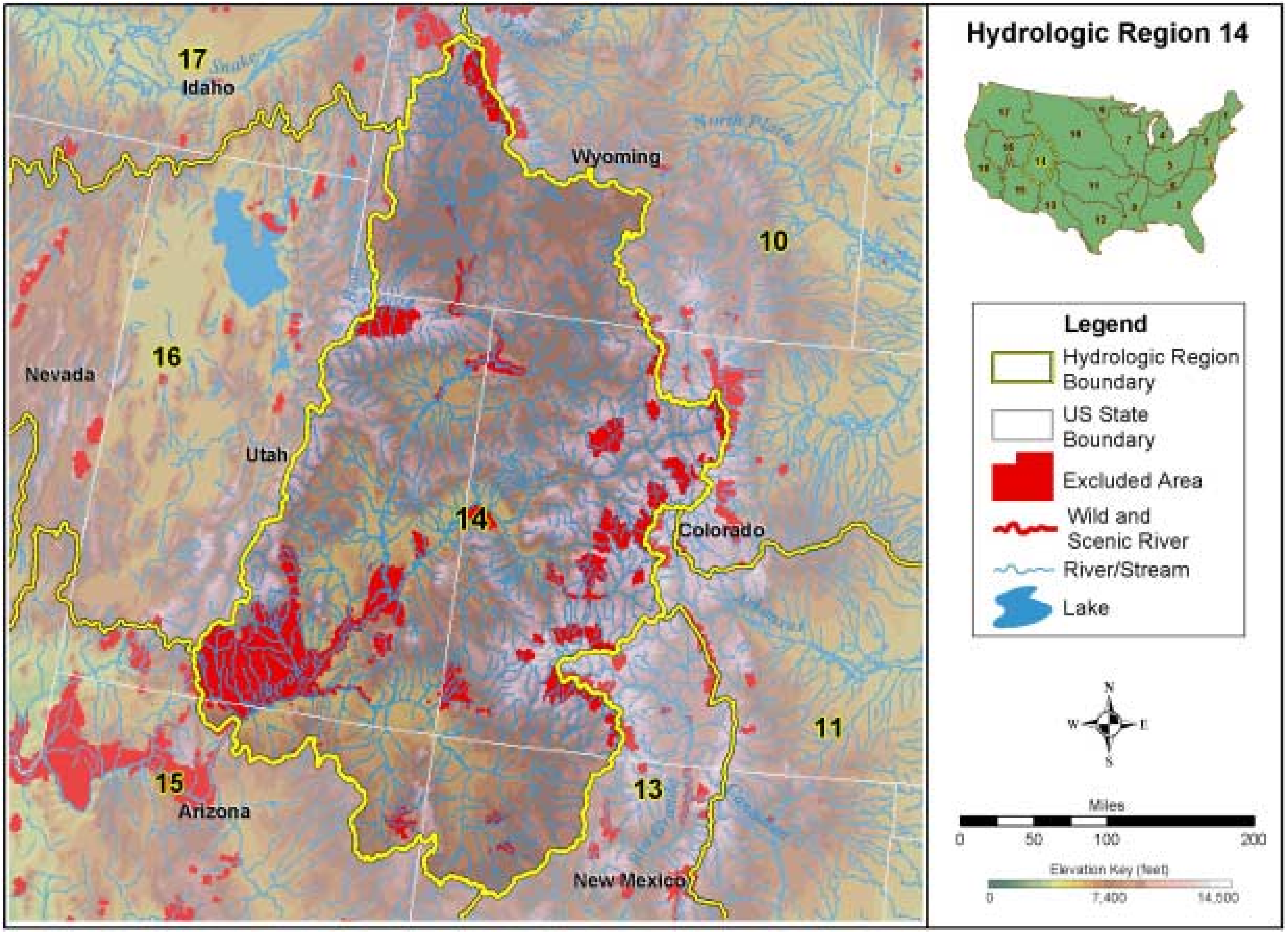


Figure A-66. Upper Colorado Region (HUC 14).

Table A-14. Summary of results of hydropower resource assessment of the Upper Colorado Region (HUC 14).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**9,489**	**724**	**2,692**	**6,073**
TOTAL HIGH POWER	**6,934**	**720**	**2,155**	**4,059**
High Head/High Power	**5,664**	**720**	**1,857**	**3,087**
Low Head/High Power	**1,270**	**0**	**298**	**972**
TOTAL LOW POWER	**2,555**	**4**	**537**	**2,014**
High Head/Low Power	**1,876**	**4**	**468**	**1,404**
Low Head/Low Power	**679**	**0**	**69**	**610**
Conventional Turbine	198	0	10	188
Unconventional Systems	103	0	14	89
Microhydro	378	0	45	333

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

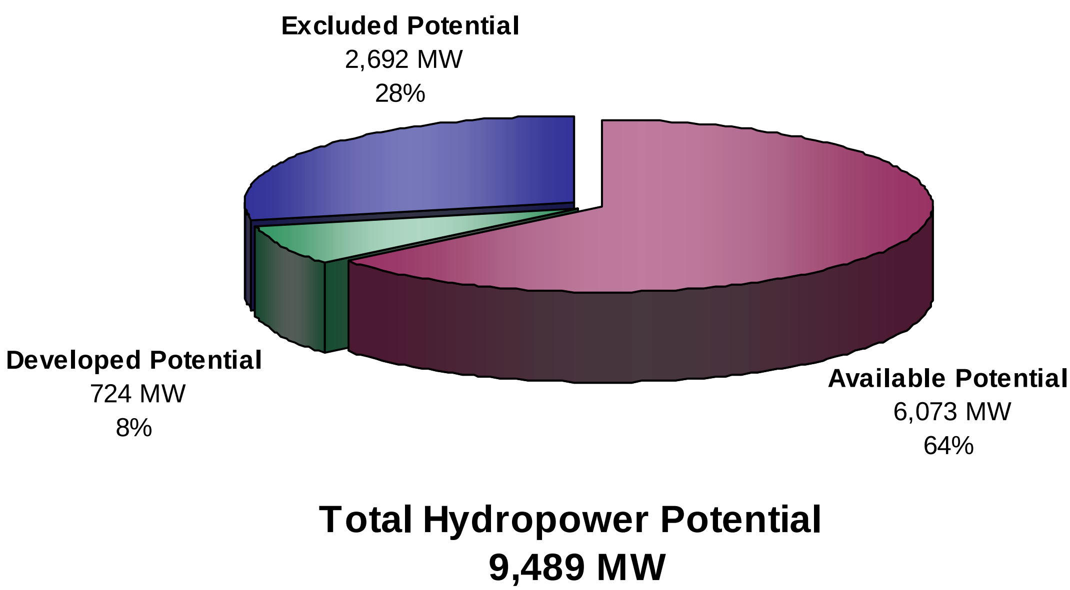


Figure A-67. Distribution of total hydropower potential in the Upper Colorado Region (HUC 14).

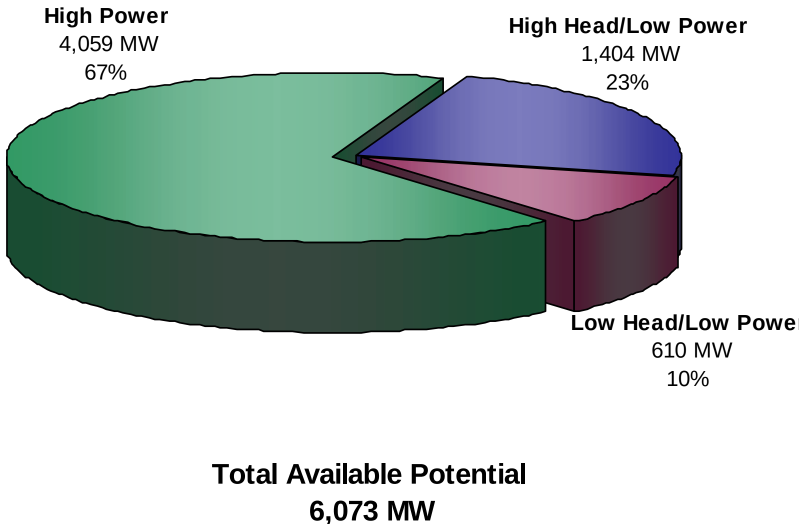


Figure A-68. Distribution of available hydropower potential in the Upper Colorado Hydrologic Region (HUC 14).

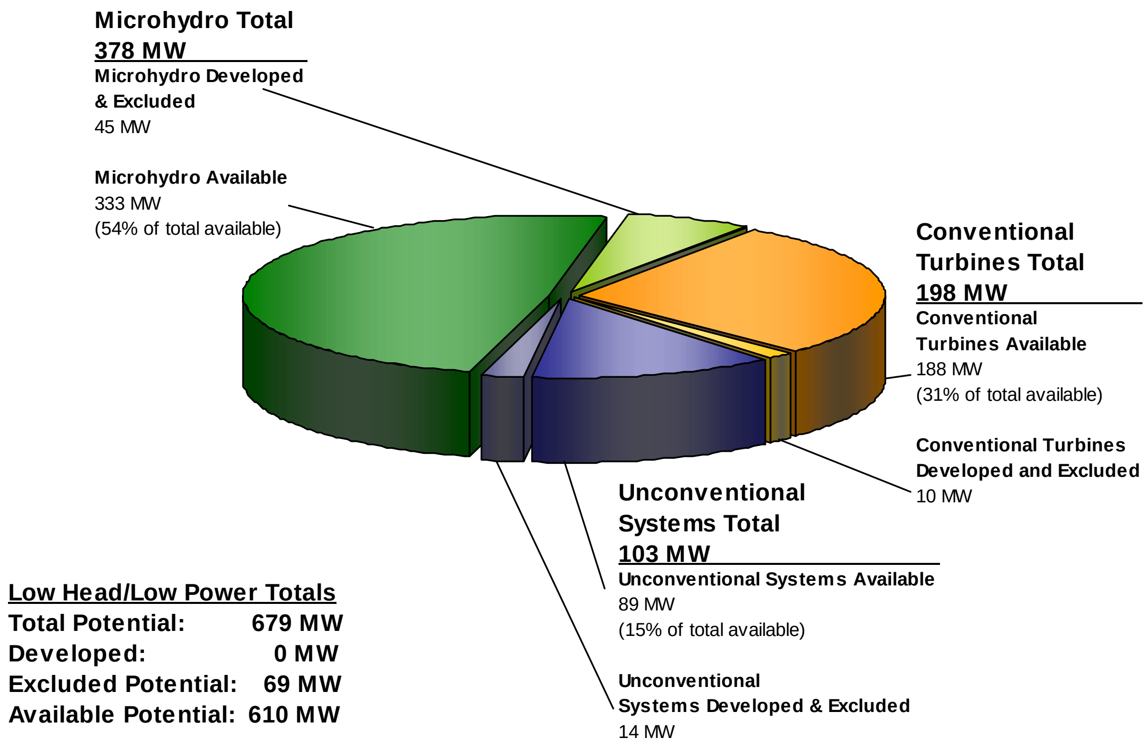


Figure A-69. Distribution of low head/low power hydropower potential in the Upper Colorado Region (HUC 14) among three low head/low power hydropower technology classes.

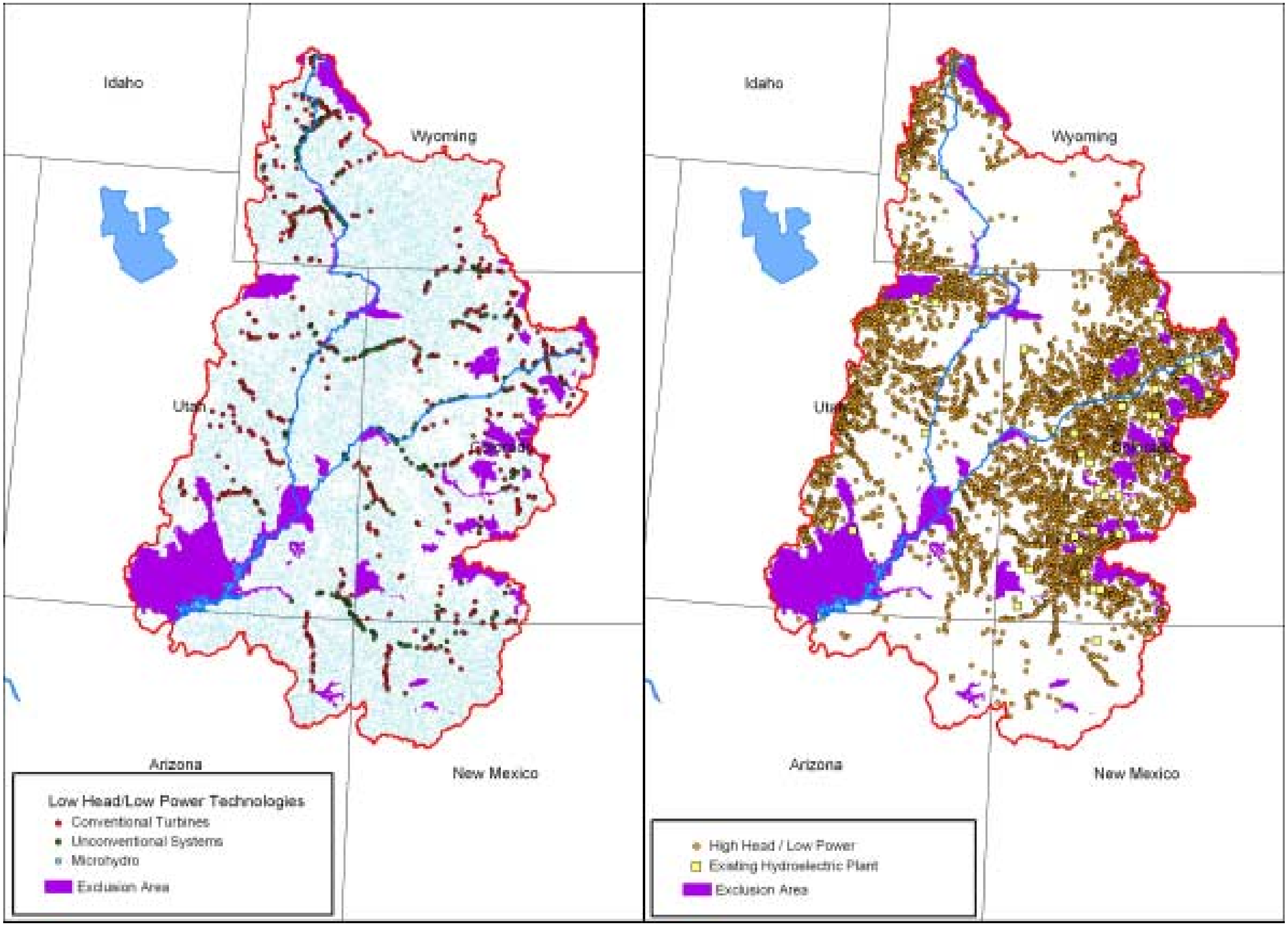


Figure A-70. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Upper Colorado Region (HUC 14).

A.15 Lower Colorado Region

A.15.1 Region Description

The topographic and hydrographic features of the Lower Colorado Region are shown in Figure A-71. The region is roughly coincident with the State of Arizona, and also includes small portions of California, Nevada, Utah, and New Mexico.

The Colorado River is the principal river in this region. Principal tributaries of the Colorado River include the Virgin River (southern Utah and Nevada) and the Salt and Gila rivers (central and southern Arizona). The largest hydropower project in this region is Lake Mead on the Colorado River. Created in the 1930s by Hoover Dam, Lake Mead provides flood control, water supply, and hydropower to several western states. Further downstream, other dams on the Colorado River formed additional reservoirs such as Lake Havasu. These reservoirs provide water for desert agriculture and major metropolitan areas in southern California, southern Nevada, and Arizona. So much water is diverted from the Colorado River in this region that only a small trickle of water reaches its outlet in the Gulf of California.

Physiographically, the Lower Colorado Region consists primarily of the southern Colorado Plateau and the southern Basin and Range Province with a transition zone between the two. The Colorado Plateau is a regional highland that covers the northern part of the region in Utah and Arizona. Although relatively flat, the Colorado Plateau also includes many mesas and buttes. It is bisected by the Grand Canyon of the Colorado River (5,000 feet deep) as well as by canyons of tributary streams. Many of these spectacular natural features are preserved as national parks, monuments, or recreation areas. In general, the Colorado Plateau is cooler and wetter than surrounding areas because of its higher elevation. The highest areas receive sufficient precipitation to sustain extensive coniferous forests, including the largest stand of ponderosa pines in the world.

The Basin and Range Province is a north-south trending series of alternating mountain ranges and tectonic valleys extending from northern Nevada to southern Arizona. The Lower Colorado Region includes the southern portions of the Basin and Range Province, i.e., the portions in southern Nevada, southeastern California, and southern Arizona. The valleys are low-lying, while the mountains can reach several thousand feet above the valley floors. The climate is semi-arid to arid with intermittent streams and desert vegetation, including desert brush and cactus. The transition zone from the Colorado Plateau to the Basin and Range Province is a series of cliffs and slopes in northeastern Arizona known as the Mogillon Rim.

A.15.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

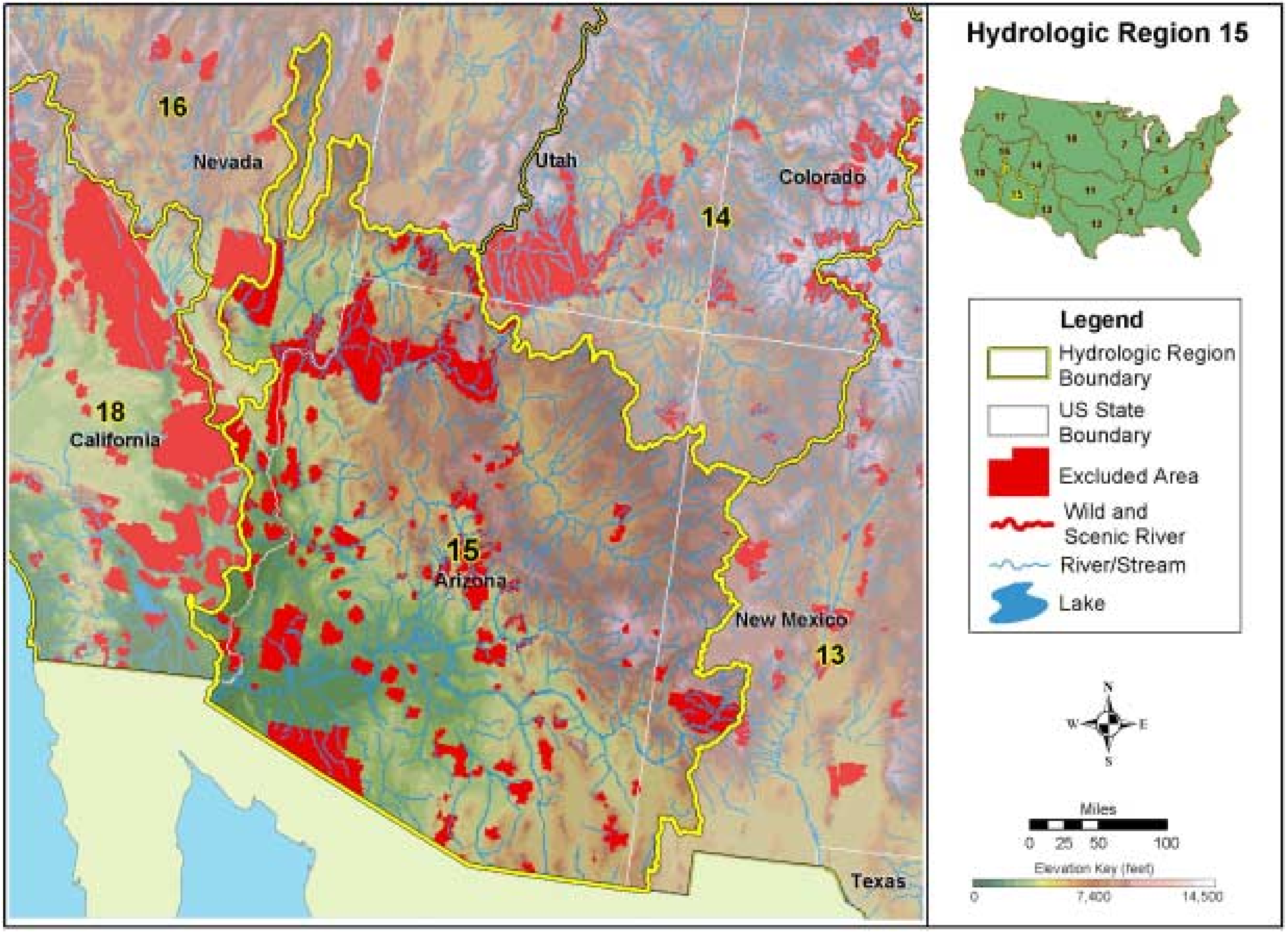


Figure A-71. Lower Colorado Region (HUC 15).

Table A-15. Summary of results of hydropower resource assessment of the Lower Colorado Region (HUC 15).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**3,452**	**789**	**931**	**1,732**
TOTAL HIGH POWER	**1,935**	**787**	**588**	**560**
High Head/High Power	**1,273**	**787**	**53**	**433**
Low Head/High Power	**662**	**0**	**535**	**127**
TOTAL LOW POWER	**1,517**	**2**	**343**	**1,172**
High Head/Low Power	**849**	**2**	**238**	**609**
Low Head/Low Power	**668**	**0**	**105**	**563**
Conventional Turbine	193	0	22	171
Unconventional Systems	55	0	13	42
Microhydro	420	0	70	350

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

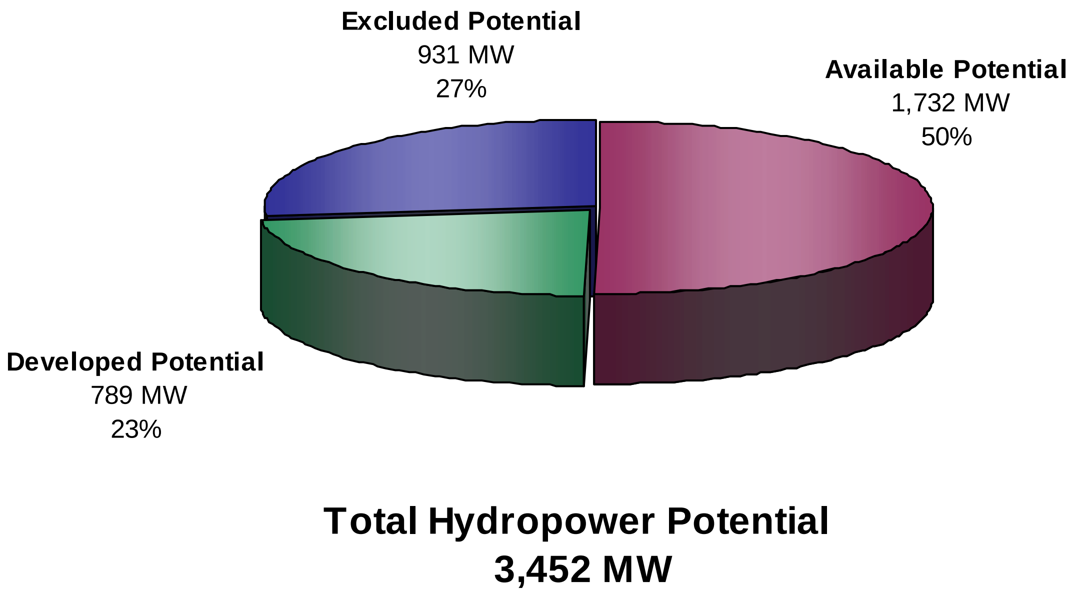


Figure A-72. Distribution of total hydropower potential in the Lower Colorado Region (HUC 15).

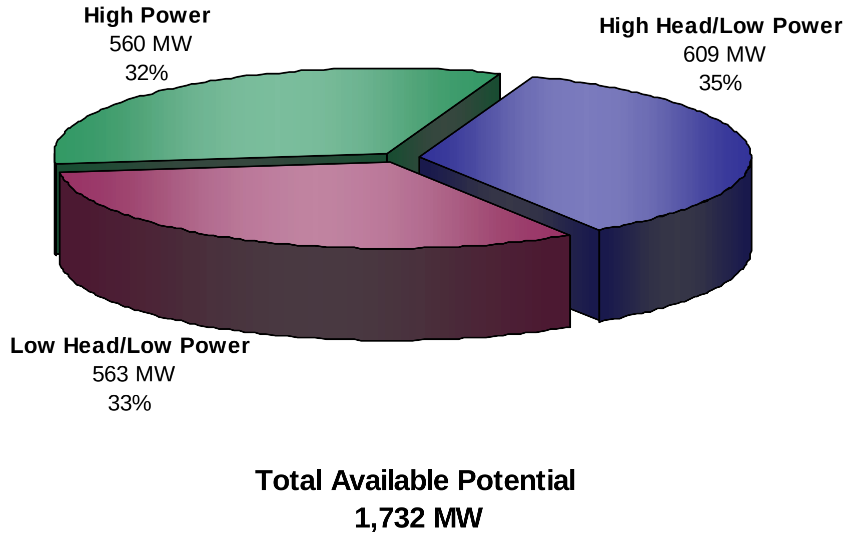


Figure A-73. Distribution of available hydropower potential in the Lower Colorado Hydrologic Region (HUC 15).

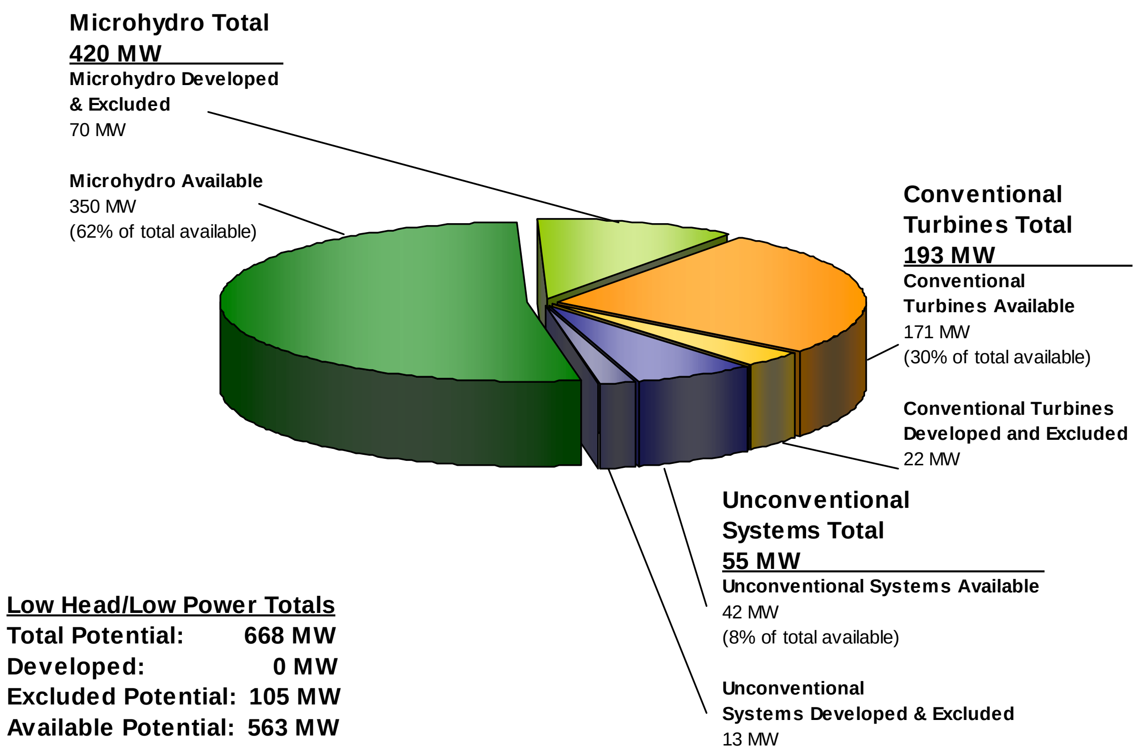


Figure A-74. Distribution of low head/low power hydropower potential in the Lower Colorado Region (HUC 15) among three low head/low power hydropower technology classes.

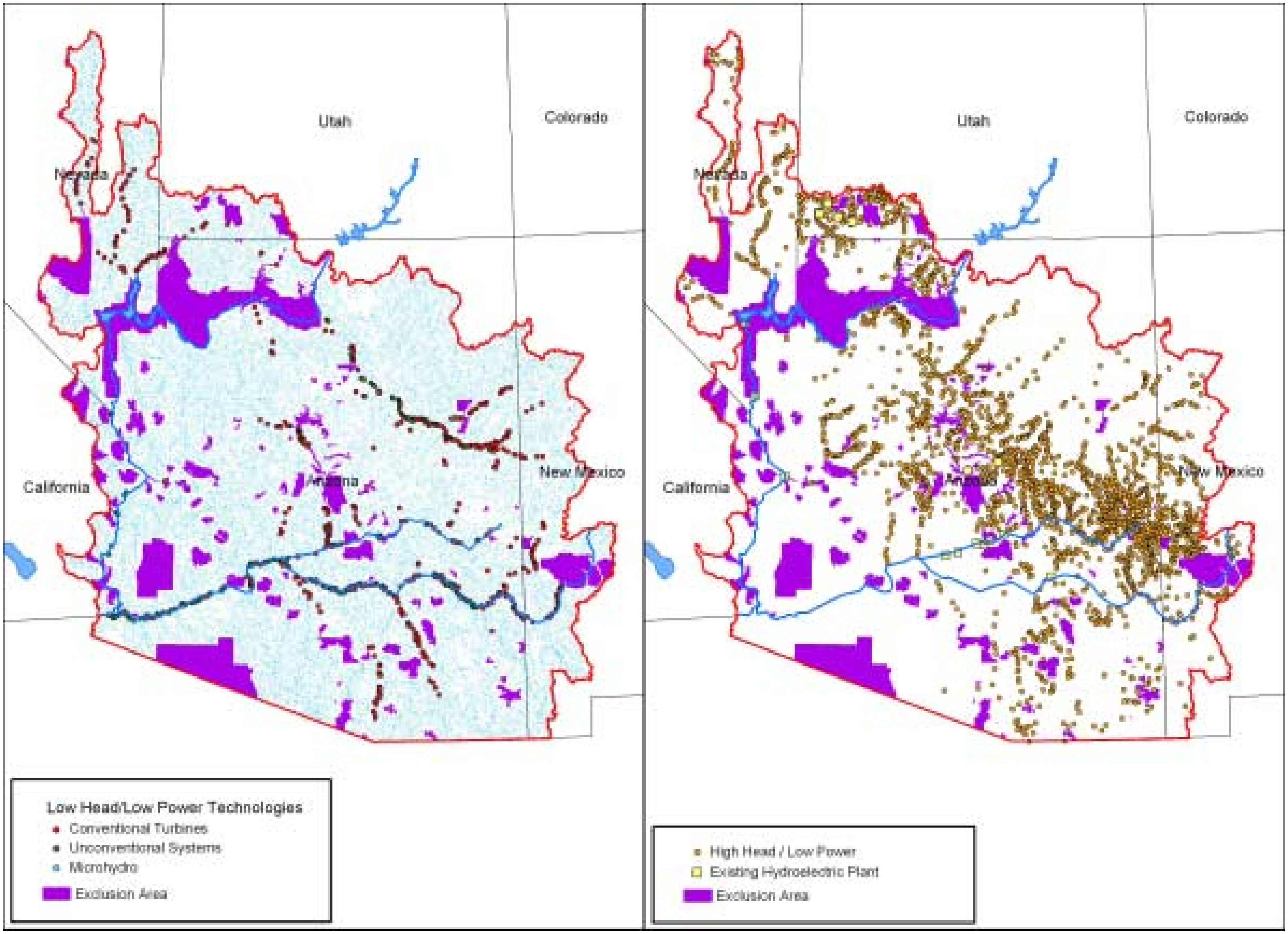


Figure A-75. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Lower Colorado Region (HUC 15).

A.16 Great Basin Region

A.16.1 Region Description

The topographic and hydrographic features of the Great Basin Region are shown in Figure A-76. The region roughly coincides with the State of Nevada and the western half of Utah. The region also includes small portions of California, Oregon, Idaho, and Wyoming.

The Great Basin is a semi-arid to arid region of interior drainage. The rivers and streams in this region have no outlet to the sea. Instead, they flow to alkali flats, mud flats, or saline lakes on the valley floors. Most of the Great Basin lies within the northern half of the Basin and Range Province, an alternating series of north-south trending mountain ranges and tectonic valleys. Valley floors range from 2,000 to 6,000 feet in elevation while mountain ranges are generally 7,000 to 9,000 feet in elevation, with some peaks exceeding 13,000 feet. The Great Basin is bounded on the west by the Sierra Nevada and nearby mountain ranges, and on the east by the Wasatch Range and the Colorado Plateau. The Great Basin lies in the rain shadow of the Sierra Nevada, which captures most of the moisture from Pacific storms. Because of the dry climate, perennial rivers and streams are found only near major mountain ranges. The principal rivers are the Truckee, Carson, and Walker Rivers, which originate in the Sierra Nevada; the Bear River, which is fed by streams in the mountains of Utah and Wyoming; and the Humboldt River of northern Nevada. Mountain ranges, such as the Sierra Nevada and the Wasatch Range, are the only areas of significant precipitation.

Lake Tahoe, the largest mountain lake in the conterminous United States, lies astride the California-Nevada state line near the western edge of the Great Basin. It is known for its depth, clarity, and scenic beauty. Most other lakes in the region are saline or brackish. The Great Salt Lake is a shallow, extensive saltwater lake covering thousands of square miles of desert flatlands northwest of Salt Lake City, Utah. By area, it is the largest lake in the western United States, but its actual size depends on the amount of precipitation falling in the nearby Wasatch Range. If the lake level rises or falls a few feet, the lakeshore can move several miles outward or inward due to the flatness of the valley floor it occupies.

The Great Basin is mostly dry, with cold winters and short, hot summers in the north. In the south, winters are shorter and milder, with long, hot summers.

A.16.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

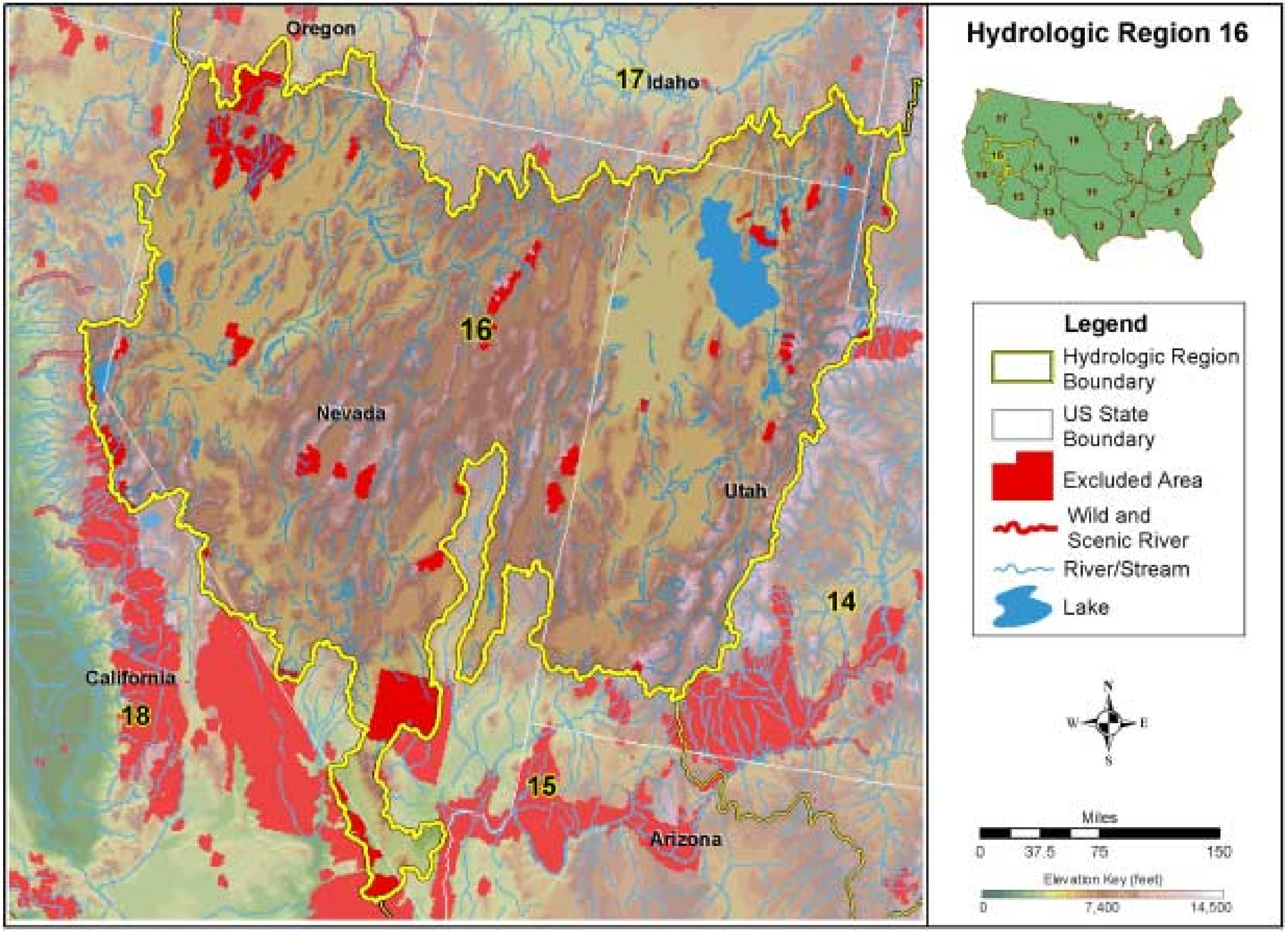


Figure A-76. Great Basin Region (HUC 16).

Table A-16. Summary of results of hydropower resource assessment of the Great Basin Region (HUC 16).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**3,043**	**98**	**452**	**2,493**
TOTAL HIGH POWER	**1,303**	**89**	**281**	**933**
High Head/High Power	**1,283**	**89**	**280**	**914**
Low Head/High Power	**20**	**0**	**1**	**19**
TOTAL LOW POWER	**1,740**	**9**	**171**	**1,560**
High Head/Low Power	**1,133**	**8**	**145**	**980**
Low Head/Low Power	**607**	**1**	**26**	**580**
Conventional Turbine	124	1	0	123
Unconventional Systems	25	0	1	24
Microhydro	458	0	25	433

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

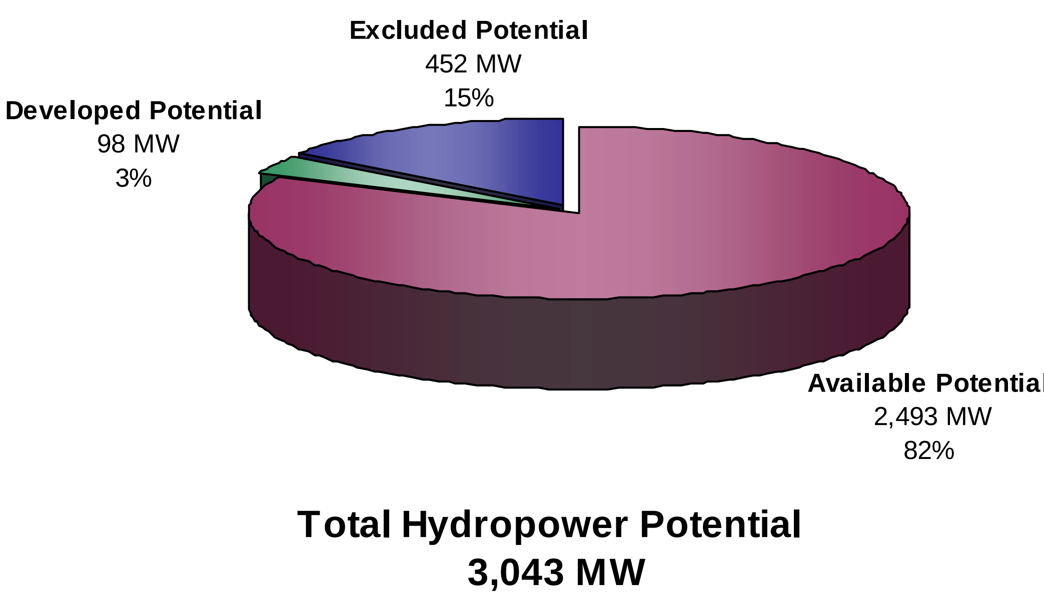


Figure A-77. Distribution of total hydropower potential in the Great Basin Region (HUC 16).

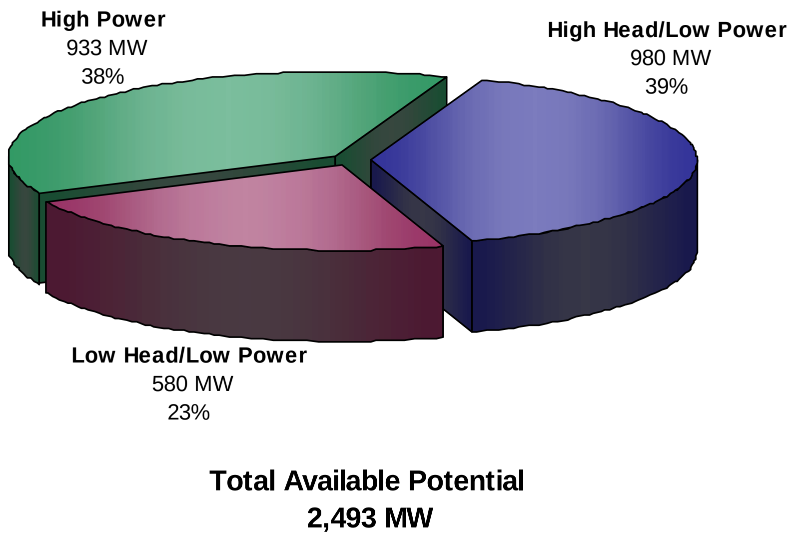


Figure A-78. Distribution of available hydropower potential in the Great Basin Hydrologic Region (HUC 16).

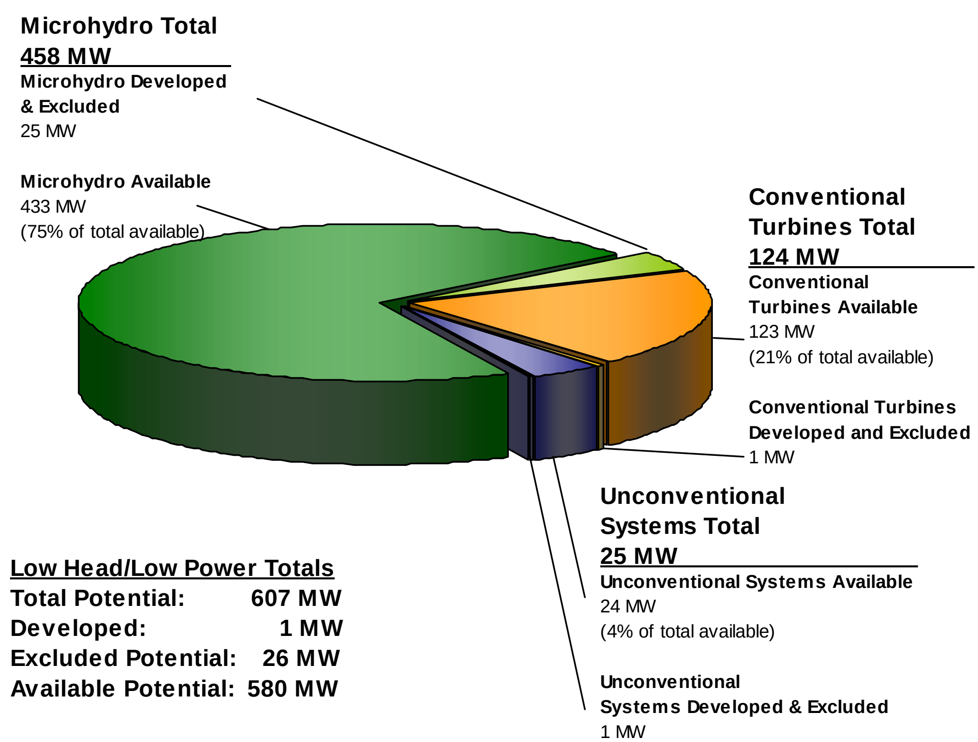


Figure A-79. Distribution of low head/low power hydropower potential in the Great Basin Region (HUC 16) among three low head/low power hydropower technology classes.

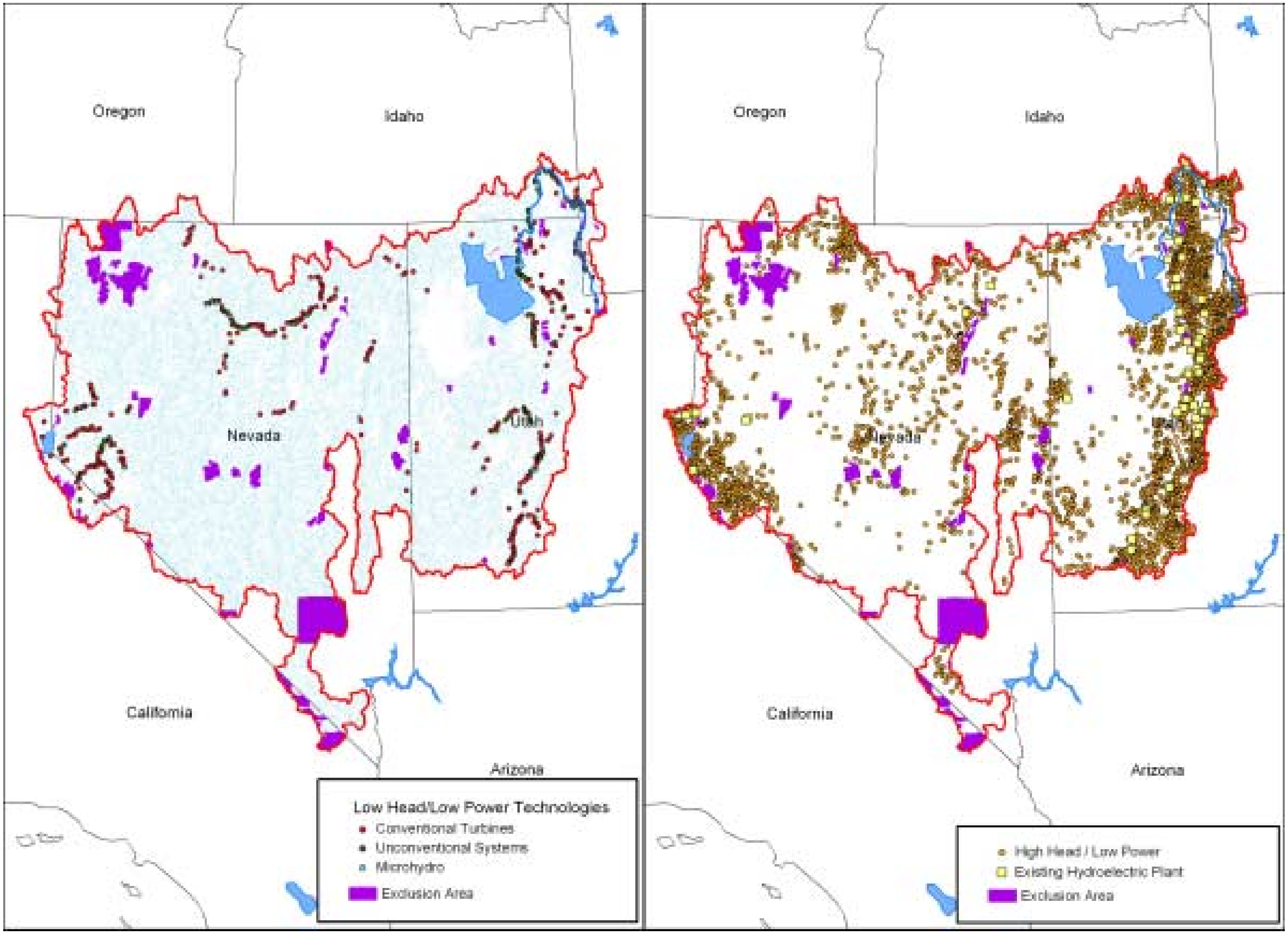


Figure A-80. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Great Basin Region (HUC 16).

A.17 Pacific Northwest Region

A.17.1 Region Description

The topographic and hydrographic features of the Pacific Northwest Region are shown in Figure A-81. The region covers the entire State of Washington, most of Oregon and Idaho, and part of western Montana. The region also includes small parts of California, Nevada, Utah, and Wyoming. Geography and climate vary significantly within the Pacific Northwest Region. Land elevations range from sea level to over 14,000 feet. The region includes high mountains, extensive plains, and deep canyons. Climatic zones range from rain forests in the west to high deserts and steppes in the central interior.

Two major mountain systems are found in the western part of the region: the Coast Range and the volcanic mountains of the Cascade Range. Oregon's Willamette Valley and Washington's Puget Sound Lowlands separate these two mountain systems. The climate of these areas are relatively wet because of their exposure to Pacific storm systems. The Columbia Plateau, east of the Cascade Range in eastern Washington and Oregon, consists primarily of extensive basalt plains dissected in some places by deep canyons. The basalt flows also extend completely across southern Idaho forming the Snake River Plain. The Rocky Mountains cover central and northern Idaho, western Montana, and westernmost Wyoming. Basin and range features (alternating mountains and valleys) occur along the interior southern border of the region in southernmost Idaho, northern Nevada, northern Utah, and northeastern California. Arid climates are dominate in the Columbia Plateau, Snake River Plain, and basin and range regions.

Two major rivers drain most of this region, the Columbia River and its largest tributary, the Snake River. The Columbia River originates in the Canadian Rockies, crossing from Canada into northern Washington. It traverses southward across the Columbia Plateau of central Washington, then bends westward to form part of the Oregon-Washington state line. During its westward flow to the Pacific Ocean, it crosses both the Cascade Ranges and the Coast Ranges. Numerous large hydropower projects, including the Grand Coulee Dam occur along the Columbia River.

The Snake River originates in western Wyoming near Yellowstone National Park. It traverses the entire length of southern Idaho along the Snake River Plain, then turns northward into Hells Canyon. The Snake River joins the Columbia in south-central Washington. Other tributaries of the Columbia include the Willamette River in western Oregon, the Flathead River and Clarks Fork in western Montana, and the Pend Oreille River in northern Idaho and Washington.

A.17.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

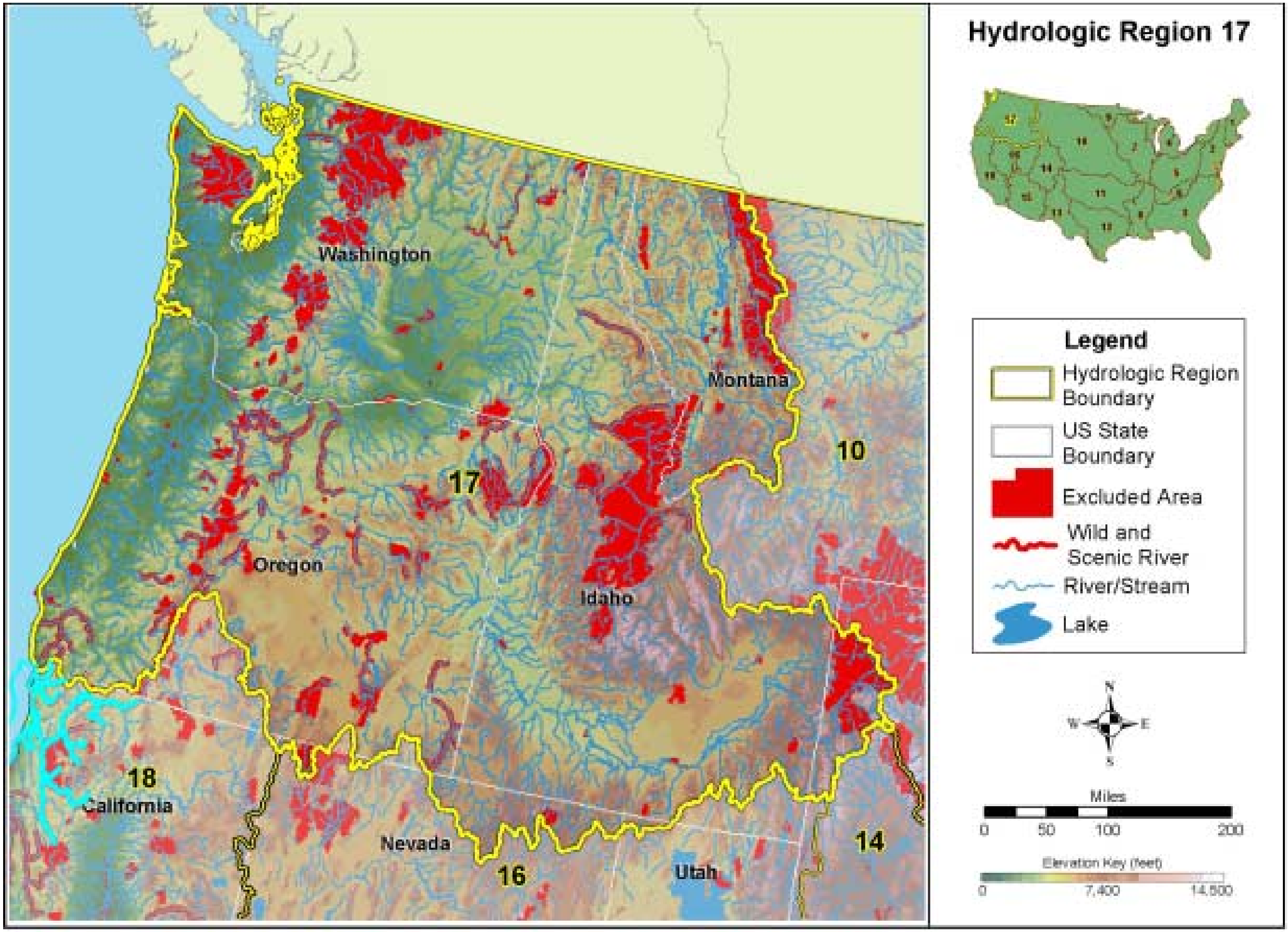


Figure A-81. Pacific Northwest Region (HUC 17).

Table A-17. Summary of results of hydropower resource assessment of the Pacific Northwest Region (HUC 17).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**76,440**	**16,677**	**20,009**	**39,754**
TOTAL HIGH POWER	**66,654**	**16,658**	**18,362**	**31,634**
High Head/High Power	**56,976**	**16,582**	**15,408**	**24,986**
Low Head/High Power	**9,678**	**76**	**2,954**	**6,648**
TOTAL LOW POWER	**9,786**	**19**	**1,647**	**8,120**
High Head/Low Power	**7,785**	**16**	**1,457**	**6,312**
Low Head/Low Power	**2,001**	**3**	**190**	**1,808**
Conventional Turbine	698	2	69	627
Unconventional Systems	312	0	58	254
Microhydro	991	1	63	927

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

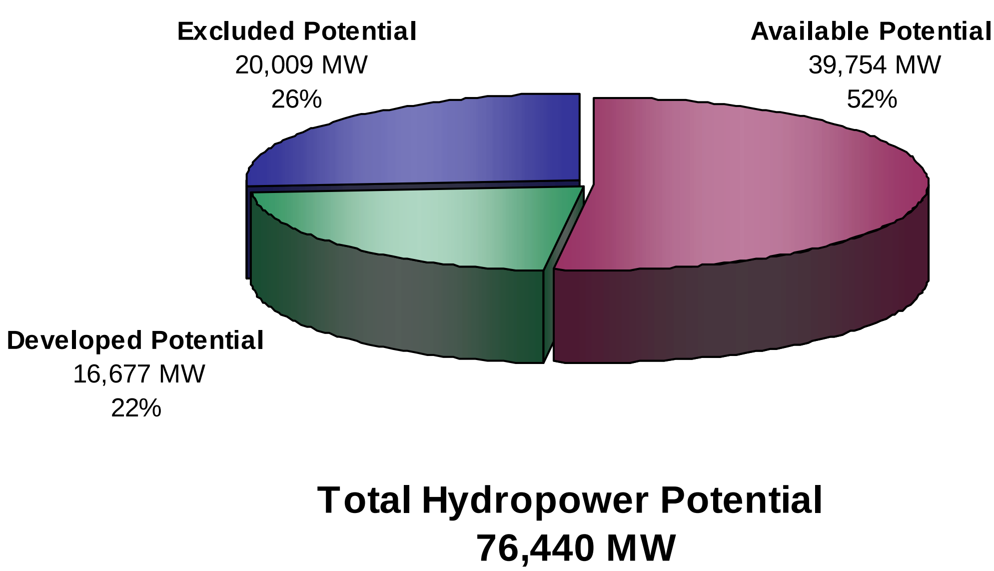


Figure A-82. Distribution of total hydropower potential in the Pacific Northwest Region (HUC 17).

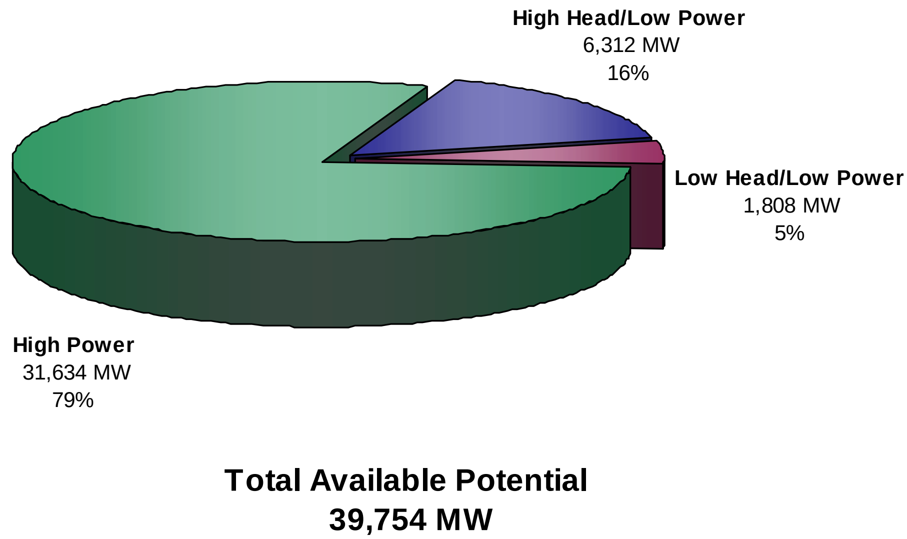


Figure A-83. Distribution of available hydropower potential in the Pacific Northwest Hydrologic Region (HUC 17).

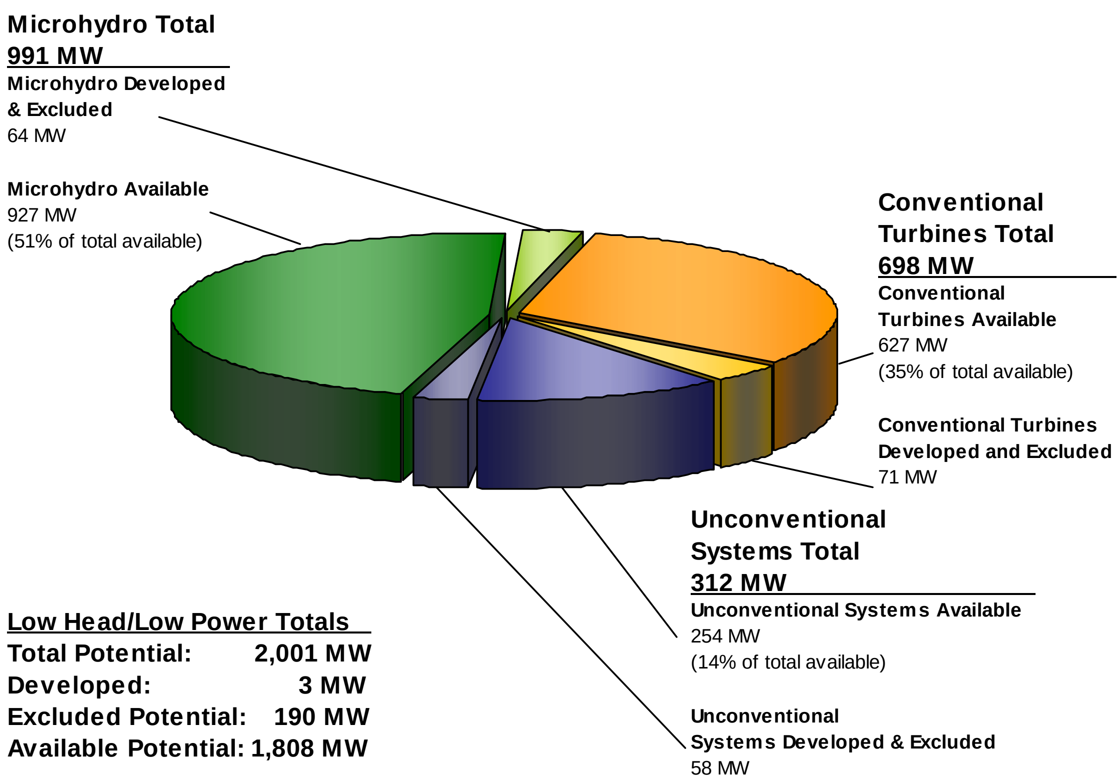


Figure A-84. Distribution of low head/low power hydropower potential in the Pacific Northwest Region (HUC 17) among three low head/low power hydropower technology classes.

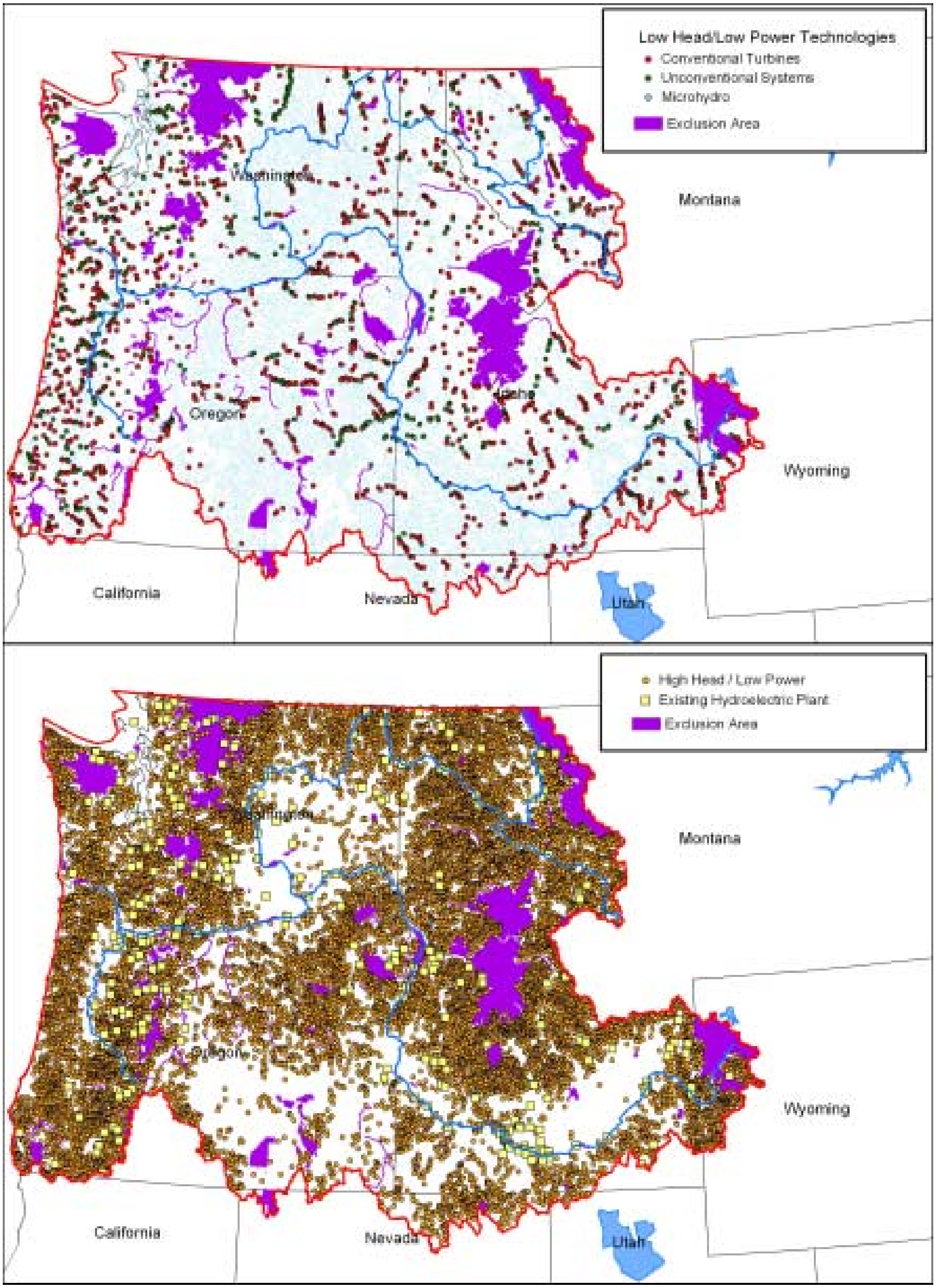


Figure A-85. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the Pacific Northwest Region (HUC 17).

A.18 California Region

A.18.1 Region Description

The topographic and hydrographic features of the California Region are shown in Figure A-86. The region is roughly coincident with the State of California, but includes small parts of Nevada and Oregon. The California Region contains a wide variety of landscapes, from damp coastal forests to empty desert waste. It contains some of the largest urban areas in the nation as well as some of the most desolate uninhabited areas. Mount Whitney, the highest point in the conterminous United States (14,496 feet) is only 85 miles from Death Valley, the lowest point in North America (280 feet below sea level).

The region consists of a steep rugged coastline directly bordered by the Coast Ranges, a series of mountain ranges that run nearly continuously from the Mexican border to the Oregon state line. These mountains are mostly 3,000 to 6,000 feet in elevation, but reach heights exceeding 11,000 feet in southern California. Coastal plains are minimal to absent, except for the moderate-sized plain underlying the Los Angeles metropolitan area. Natural bays and harbors are generally lacking, with the notable exceptions of San Diego Bay and San Francisco Bay. The Great Central Valley lies inland from the Coast Ranges, extending 400 miles from north to south in central and northern California. Beyond the Central Valley rises the Sierra Nevada, a continuous 400-mile long fault block range that rises to heights exceeding 14,000 feet. In southern California, desert landscapes dominate the areas behind the Coast Ranges. These include desert mountain ranges alternating with deep valleys or alluvial plains.

The high mountains consist of extensive coniferous forests in the north, to mixed forest and shrubland in the south. The lowest desert valleys contain dry salt and alkali flats, with extremely hot temperatures in the summer (exceeding 120°F in Death Valley). The principal population centers are near the natural harbors or coastal plains, namely the San Francisco, Los Angeles, and San Diego metropolitan areas. Other major cities such as Sacramento and Fresno are in the agricultural heartland of the Central Valley. All these cities have extended suburbs and contain many of the 30 million inhabitants of the region. By contrast, much of the inland desert is sparsely populated.

The principal rivers include the Sacramento and San Joaquin Rivers, whose tributary streams drain the western slopes of the Sierra Nevada. Other rivers include the Klamath, Trinity, and Eel Rivers, which flow from the northern Coast Ranges directly into the Pacific Ocean. In general, the rivers are not navigable. However, deep ship channels extend from San Francisco Bay into the Central Valley to the inland ports of Sacramento and Stockton.

Most of the California Region has a Mediterranean climate, with cool, wet winters and long, dry summers with little or no rainfall between May and November. The domestic and agricultural water supply for the region’s 30 million inhabitants comes in great part from winter Pacific storms originating in the Gulf of Alaska. The storms drop their moisture on the Coast Ranges and Sierra Nevada as rainfall and snowfall, respectively. Most of this precipitation is stored as winter snowpack in the Sierra, which is captured in reservoirs constructed on most of the streams draining the slopes of the Sierra. These reservoirs provide water storage, flood control, recreation, and hydropower for the region. The water stored in these reservoirs is used both for agriculture and domestic use. The major population centers near the coast (San Francisco, Los Angeles, and San Diego) import mountain stream water from hundreds of miles away using a vast network of canals and aqueducts. The aqueducts serving southern California import water from the Sierra Nevada and the Colorado River, crossing desert and mountain ranges to supply a large population.

A.18.2 Summary Assessment Results

The summary results for this hydrologic region are presented in the remainder of this section in the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class

- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential

- Pie chart showing the high power, high head/low power, and low head/low power fractions of the total available hydropower potential

- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes

- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

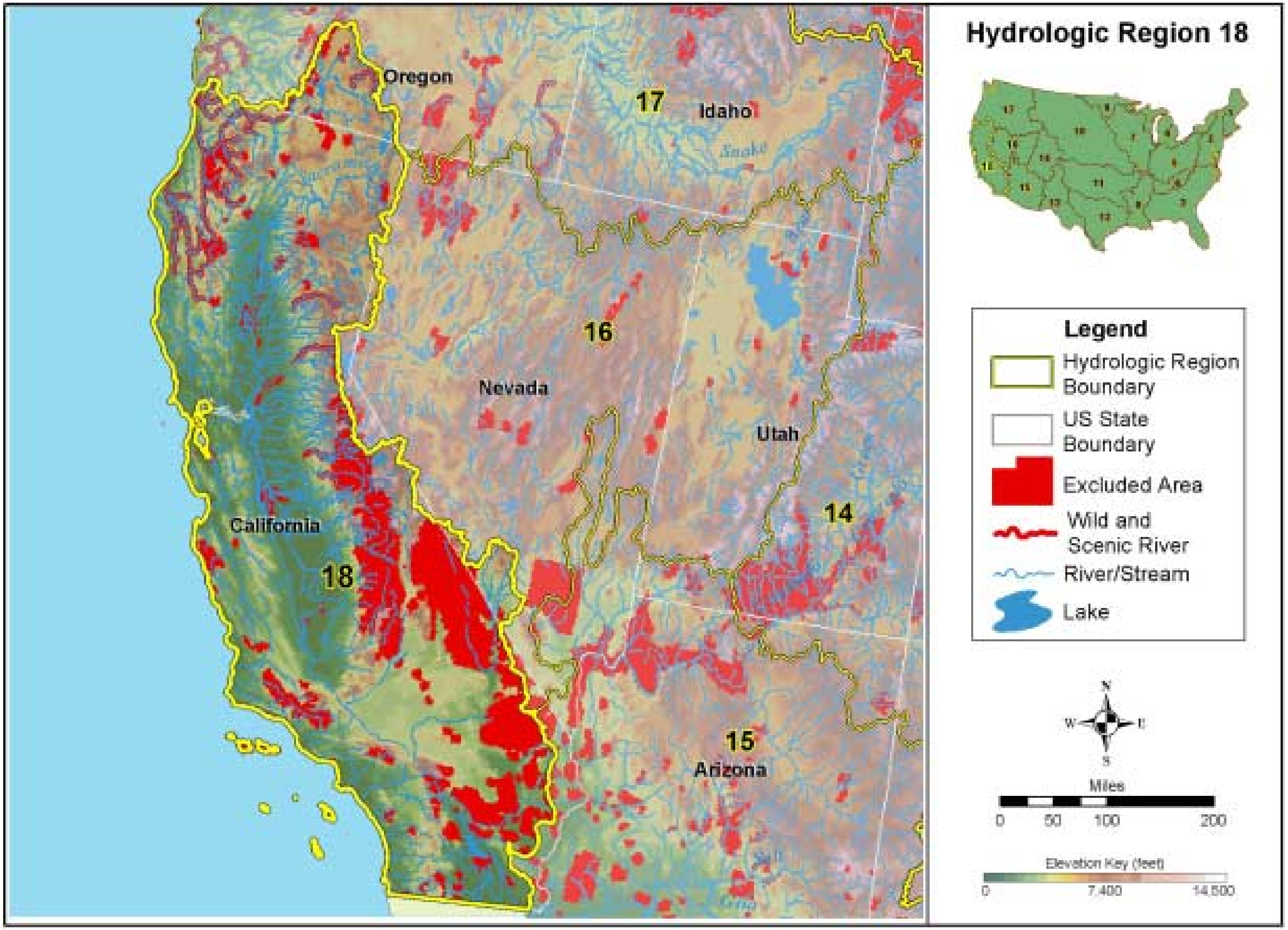


Figure A-86. California Region (HUC 18).

Table A-18. Summary of results of hydropower resource assessment of the California Region (HUC 18).

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**26,953**	**4,675**	**12,043**	**10,235**
TOTAL HIGH POWER	**23,192**	**4,647**	**10,897**	**7,648**
High Head/High Power	**21,669**	**4,621**	**9,864**	**7,184**
Low Head/High Power	**1,523**	**26**	**1,033**	**464**
TOTAL LOW POWER	**3,761**	**28**	**1,146**	**2,587**
High Head/Low Power	**2,946**	**24**	**987**	**1,935**
Low Head/Low Power	**815**	**4**	**159**	**652**
Conventional Turbine	239	2	39	198
Unconventional Systems	103	1	25	77
Microhydro	473	1	95	377

Note: No feasibility or availability assessments have been performed. “Available” only indicates net potential after subtracting developed and excluded potentials from total potential.

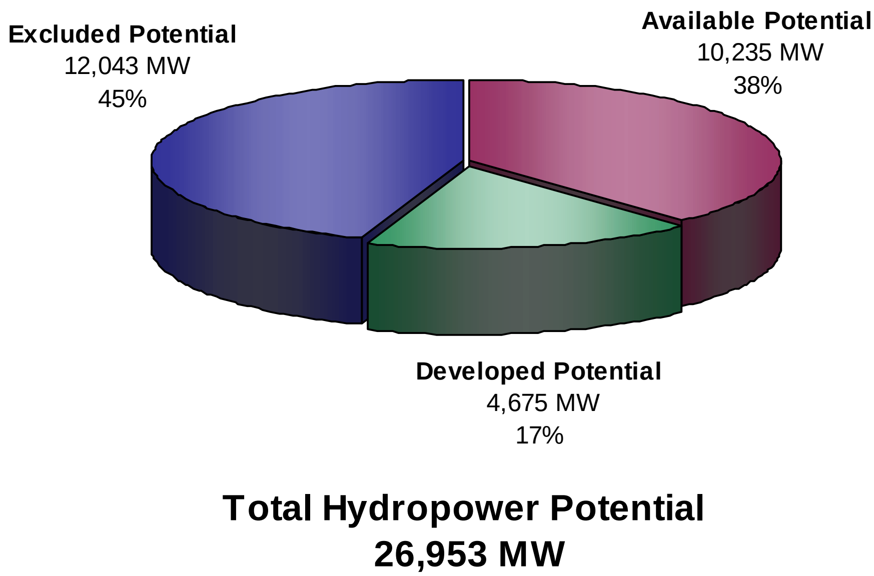


Figure A-87. Distribution of total hydropower potential in the California Region (HUC 18).

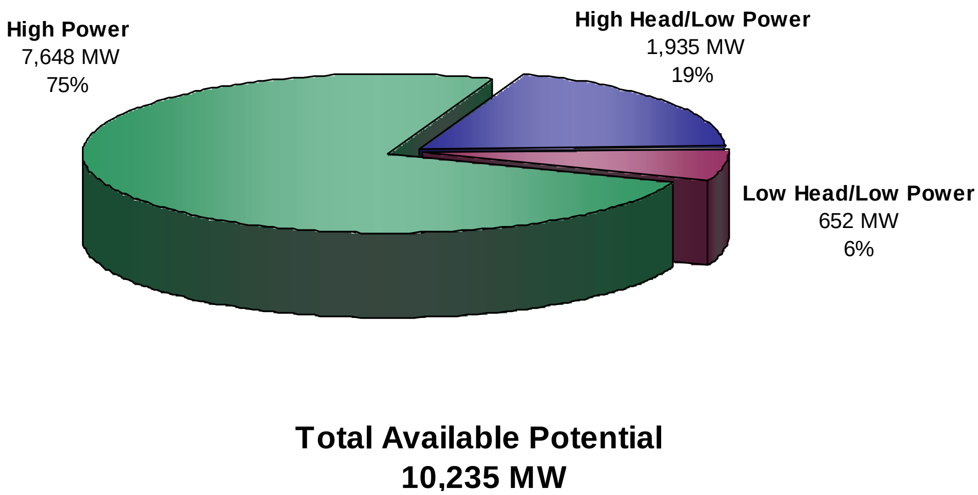


Figure A-88. Distribution of available hydropower potential in the California Hydrologic Region (HUC 18).

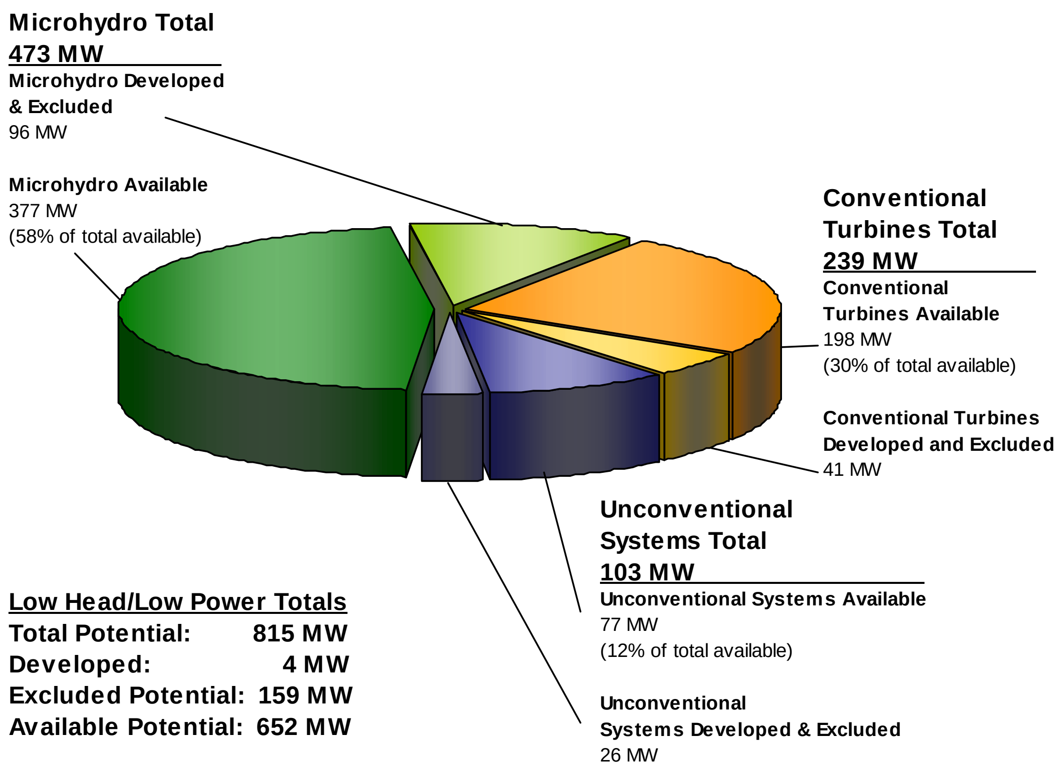


Figure A-89. Distribution of low head/low power hydropower potential in the California Region (HUC 18) among three low head/low power hydropower technology classes.

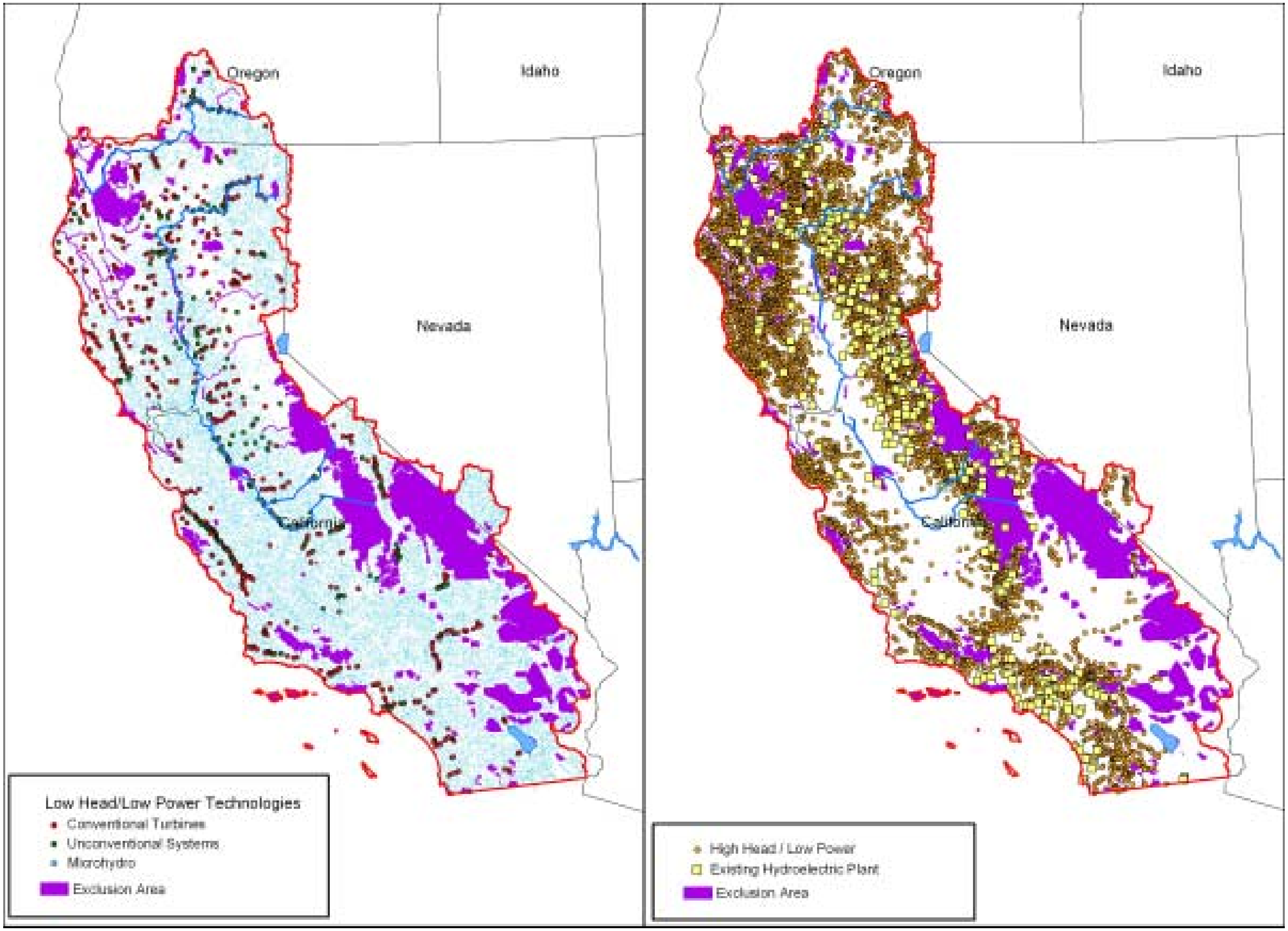


Figure A-90. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in the California Region (HUC 18).

Appendix B

Assessment Results by State

Appendix B

Assessment Results by State

This appendix contains results of the hydropower assessments of the 48 states of the conterminous U.S. The state results are presented in the two part table, Table B-0, to facilitate lookup of hydropower potential values and comparison of these values amongst the states. This summary information is followed by 48 sections, each developed to a particular state. Each section has the same format, which includes the following tables and figures:

- Table of total, developed, excluded, and available hydropower potential by power class
- Pie chart showing the developed, excluded, and available fractions of the total hydropower potential
- Pie chart showing the high power, high head/ low power, and low head/low power fractions of the total available hydropower potential
- Pie chart showing the fractions of the low head/low power hydropower potential corresponding to the operating envelopes of conventional turbines, unconventional systems, and microhydro technology classes
- Two panel power potential distribution map with the upper panel showing the locations of low head/low power hydropower potential sites differentiated by the corresponding low head/low power hydropower technology class and the lower panel showing the locations of existing hydroelectric power plants and sites of high head/low power potential.

Negative available hydropower potential values in the high head/high power class occurred for six states: Florida, Iowa, Nebraska, Nevada, North Dakota, and South Dakota. In addition, negative excluded hydropower potential values in the high head/high power class occurred for two of these states: Nevada and South Dakota. The negative values are attributable to one or a combination of underestimating of the total hydropower potential and overestimating the developed hydropower potential, or underestimating the amount of excluded potential and overestimating the amount of developed potential in exclusion areas. Because the negative values are not realistic, they were set equal to zero. For these states, the available hydropower potential for the high power class is equal to the available potential in the low head/high power class, and the total available potential is the sum of the high power and low power class values. For the available potentials calculated this way, available potential is not equal to total potential minus the sum of the developed and excluded values.

The summary table for each of the six states shows values that were originally negative to be unknown by the presence of a bar in that cell in the table. Table B-0 and the individual states summary tables also show any available potential values resulting from elimination of the unrealistic negative values in yellow font on a green background. Since it is unknown which of the values of total, developed, and excluded potential are causing the negative values, the total power values for these power categories were not modified (except in the cases of total excluded potential for Nevada and South Dakota where negative excluded potentials occurred for the high head/high power class). Also, since the total power values of available potential were simply rollups of low power and high power values rather than calculated by subtracting developed and excluded potential from the total potential, Table B-0B, which shows percentages, and the figure showing the distribution of total power potential among its constituent parts for each of the six states show percentages that sum to greater than 100%.

The results presented in this appendix do not include any assessment of the feasibility of developing or the actual availability for development of any hydropower resources. The term “available” used in the tables and figures in this appendix only denotes the net amount of hydropower potential after subtracting the amounts of developed and excluded hydropower potential from the gross amount of hydropower potential.

Table B-0A. Summary of state hydropower potentials by category and power class.

Total Potential				Available Potential			Available Low Head/Low Power Potential		
Total (MW)	Developed (MW)	Excluded (MW)	Available (MW)	High Power (MW)	High Head/ Low Power (MW)	Low Head/ Low Power (MW)	Conventional Turbines (MW)	Unconventional Systems (MW)	Microhydro (MW)
3,166	1,114	44	2,008	1,168	240	600	240	91	269
3,587	929	1,244	1,414	481	466	467	154	38	275
4,904	406	407	4,092	3,280	324	488	155	110	223
26,638	4,706	11,628	10,306	7,737	1,941	627	197	76	354
7,413	246	2,275	4,892	2,974	1,333	585	239	59	287
432	55	18	359	206	102	51	15	11	25
24	0	0	24	15	2	7	1	2	4
446	32	14	408	184	13	211	41	70	100
2,249	429	208	1,612	829	231	552	186	123	243
18,794	1,293	5,545	11,956	9,371	2,044	541	179	71	291
1,902	27	297	1,578	1,145	39	394	104	100	190
1,587	67	4	1,516	1,124	82	310	116	61	133
1,124	96	127	954	412	49	493	184	108	201
909	1	3	905	417	38	530	191	80	259
4,115	382	46	3,687	3,111	197	379	136	49	195
2,236	89	129	2,018	1,764	11	243	68	72	103
2,766	431	71	2,264	1,503	471	290	109	39	142
844	202	298	344	211	74	59	21	3	35
675	126	29	520	349	109	62	21	6	35
1,220	209	224	787	179	188	420	159	51	210
1,410	128	249	1,033	443	168	422	139	72	211
4,496	0	450	4,046	3,477	61	508	172	127	209
4,549	129	117	4,303	3,394	186	723	277	98	348
6,379	1,192	2,179	3,008	1,513	899	596	208	91	297
1,223	153	103	1,045	426	69	550	280	71	199
1,137	263	147	789	6	371	412	68	8	336
1,181	187	89	905	568	246	91	36	16	39
301	7	37	257	167	38	52	20	5	27
1,729	30	368	1,331	383	490	458	110	36	312
4,902	2,862	110	1,930	400	1,051	479	183	69	227
2,751	610	491	1,650	904	382	364	120	71	173
209	270	8	199	40	15	138	36	10	93
1,200	63	81	1,136	604	144	388	152	54	182
1,511	239	23	1,249	481	114	654	282	152	220
18,397	3,296	5,836	9,266	6,658	1,937	671	230	89	352
4,754	284	488	3,982	2,534	949	499	186	56	257
38	4	0	34	14	9	11	4	1	6
1,324	429	49	846	503	81	262	70	79	113
858	622	67	468	42	102	324	117	32	176
5,283	1,081	472	3,730	2,900	397	433	145	78	210
2,336	189	119	2,028	355	243	1,430	443	242	746
3,924	136	933	2,856	1,506	977	373	87	32	254
1,145	128	49	968	527	355	86	37	15	34
2,220	147	194	1,879	1,114	413	352	130	49	173
30,803	11,470	6,893	12,440	10,638	1,392	410	138	74	198
3,428	141	753	2,534	1,847	452	235	83	33	119
1,595	264	189	1,142	591	141	410	138	68	204
6,059	118	2,768	3,173	1,903	802	468	194	47	227
208,414	**35,279**	**45,872**	**119,950**	**80,404**	**20,438**	**19,108**	**6,599**	**2,995**	**9,514**

Note 1: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.
Note 2: The U.S. total, excluded, and available potentials listed in Table A-0 are 4-5% higher than the values in this table, which contains more accurate U.S. values.
Note 3: Numbers in yellow font indicate that sums by potential category and power class do not match; see state summary for explanation.

Table B-0B. Summary of state hydropower percentages of totals by category and power class.

	Total Potential				Available Potential			Available Low Head/Low Power Potential		
Name	Total[a]	Developed[b]	Excluded[b]	Available[b]	High Power[c]	High Head/ Low Power[c]	Low Head/ Low Power[c]	Conventional Turbines[d]	Unconventional Systems[d]	Microhydro[d]
Alabama	2%	35%	1%	63%	58%	12%	30%	40%	15%	45%
Arizona	2%	26%	35%	39%	34%	33%	33%	33%	8%	59%
Arkansas	2%	8%	8%	83%	80%	8%	12%	32%	23%	46%
California	13%	18%	44%	39%	75%	19%	6%	31%	12%	56%
Colorado	4%	3%	31%	66%	61%	27%	12%	41%	10%	49%
Connecticut	0%	13%	4%	83%	57%	28%	14%	29%	22%	49%
Delaware	0%	0%	0%	100%	63%	8%	29%	14%	29%	57%
Florida	0%	7%	3%	92%	45%	3%	52%	19%	33%	47%
Georgia	1%	19%	9%	72%	51%	14%	34%	34%	22%	44%
Idaho	9%	7%	30%	64%	78%	17%	5%	33%	13%	54%
Illinois	1%	1%	16%	83%	73%	2%	25%	26%	25%	48%
Indiana	1%	4%	0%	96%	74%	5%	20%	37%	20%	43%
Iowa	1%	8%	11%	85%	43%	5%	52%	37%	22%	41%
Kansas	0%	0%	0%	100%	42%	4%	54%	36%	15%	49%
Kentucky	2%	9%	1%	90%	84%	5%	10%	36%	13%	51%
Louisiana	1%	4%	6%	90%	87%	1%	12%	28%	30%	42%
Maine	1%	16%	3%	82%	66%	21%	13%	38%	13%	49%
Maryland	0%	24%	35%	41%	61%	22%	17%	36%	5%	59%
Massachusetts	0%	19%	4%	77%	67%	21%	12%	34%	10%	56%
Michigan	1%	17%	18%	64%	23%	24%	53%	38%	12%	50%
Minnesota	1%	9%	18%	73%	43%	16%	41%	33%	17%	50%
Mississippi	2%	0%	10%	90%	86%	2%	13%	34%	25%	41%
Missouri	2%	3%	3%	95%	79%	4%	17%	38%	14%	48%
Montana	3%	19%	34%	47%	50%	30%	20%	35%	15%	50%
Nebraska	1%	12%	8%	85%	41%	7%	53%	51%	13%	36%
Nevada	1%	23%	11%	69%	1%	47%	52%	17%	2%	82%
New Hampshire	1%	16%	8%	77%	63%	27%	10%	40%	18%	43%
New Jersey	0%	2%	12%	85%	65%	15%	20%	38%	10%	52%
New Mexico	1%	2%	21%	77%	29%	37%	34%	24%	8%	68%
New York	2%	58%	2%	39%	21%	54%	25%	38%	14%	47%
North Carolina	1%	22%	18%	60%	55%	23%	22%	33%	20%	48%
North Dakota	0%	93%	3%	69%	23%	8%	69%	25%	7%	67%
Ohio	1%	5%	6%	89%	53%	13%	34%	39%	14%	47%
Oklahoma	1%	16%	2%	83%	39%	9%	52%	43%	23%	34%
Oregon	9%	18%	32%	50%	72%	21%	7%	34%	13%	52%
Pennsylvania	2%	6%	10%	84%	64%	24%	13%	37%	11%	52%
Rhode Island	0%	10%	0%	90%	41%	26%	32%	36%	9%	55%
South Carolina	1%	32%	4%	64%	59%	10%	31%	27%	30%	43%
South Dakota	0%	72%	8%	55%	9%	22%	69%	36%	10%	54%
Tennessee	3%	20%	9%	71%	78%	11%	12%	33%	18%	48%
Texas	1%	8%	5%	87%	18%	12%	71%	31%	17%	52%
Utah	2%	3%	24%	73%	53%	34%	13%	23%	9%	68%
Vermont	1%	11%	4%	85%	54%	37%	9%	43%	17%	40%
Virginia	1%	7%	9%	85%	59%	22%	19%	37%	14%	49%
Washington	15%	37%	22%	40%	86%	11%	3%	34%	18%	48%
West Virginia	2%	4%	22%	74%	73%	18%	9%	35%	14%	51%
Wisconsin	1%	17%	12%	72%	52%	12%	36%	34%	17%	50%
Wyoming	3%	2%	46%	52%	60%	25%	15%	41%	10%	49%
U.S. Average		18%	23%	60%	67%	17%	16%	35%	16%	50%

a. Regional percentage of total U.S. hydropower potential
b. Percentage of regional total hydropower potential
c. Percentage of regional total available hydropower potential
d. Percentage of regional total low head/low power hydropower potential

Note 1: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.
Note 2: Bolded figures indicate values greater than or equal to the U.S. average.
Note 3: Blue background indicates constituent with the largest percentage
Note 4: Numbers in yellow font indicate that sums by potential category and power class do not match; see state summary for explanation.

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B.1 Alabama

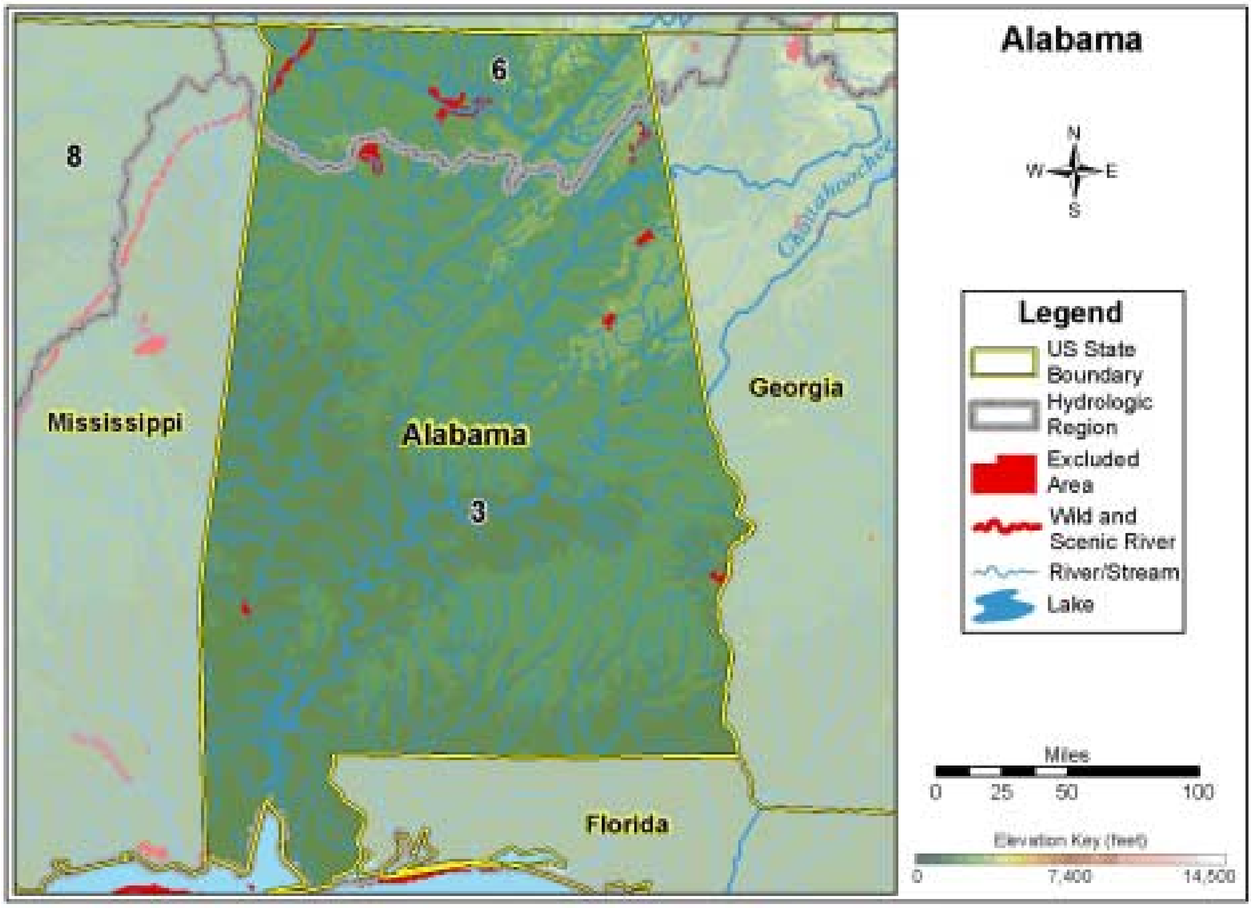


Figure B-1. Alabama.

Table B-1. Summary of results of hydropower resource assessment of Alabama.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**3,165**	**1,113**	**44**	**2,008**
TOTAL HIGH POWER	**2,312**	**1,113**	**31**	**1,168**
High Head/High Power	**1,491**	**1,113**	**22**	**356**
Low Head/High Power	**821**	**0**	**9**	**812**
TOTAL LOW POWER	**853**	**0**	**13**	**840**
High Head/Low Power	**246**	**0**	**6**	**240**
Low Head/Low Power	**607**	**0**	**7**	**600**
Conventional Turbine	242	0	2	240
Unconventional Systems	93	0	2	91
Microhydro	272	0	3	269

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

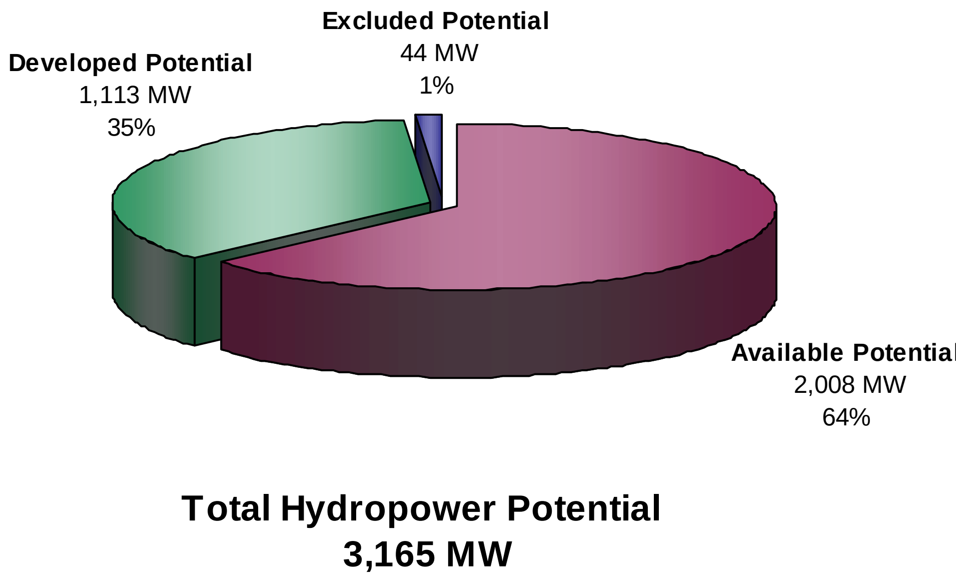


Figure B-2. Distribution of total hydropower potential in Alabama.

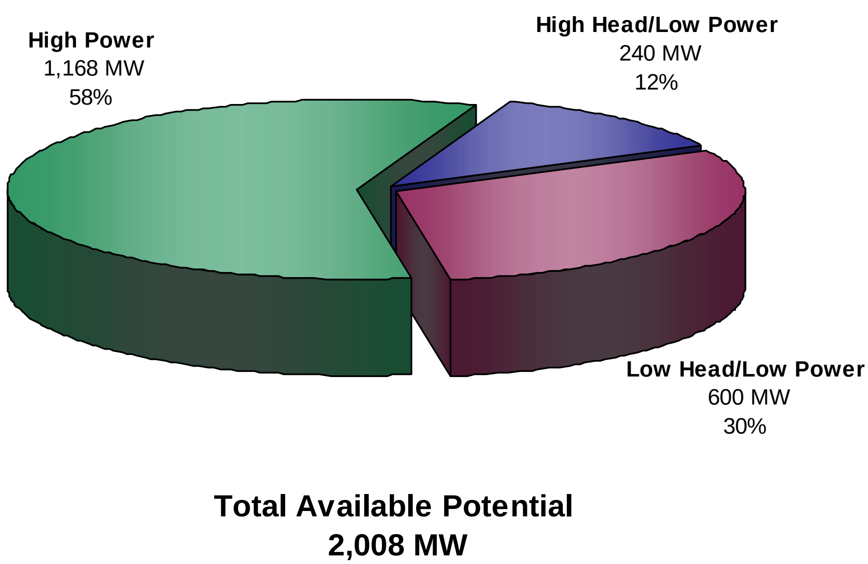


Figure B-3. Distribution of available hydropower potential in Alabama.

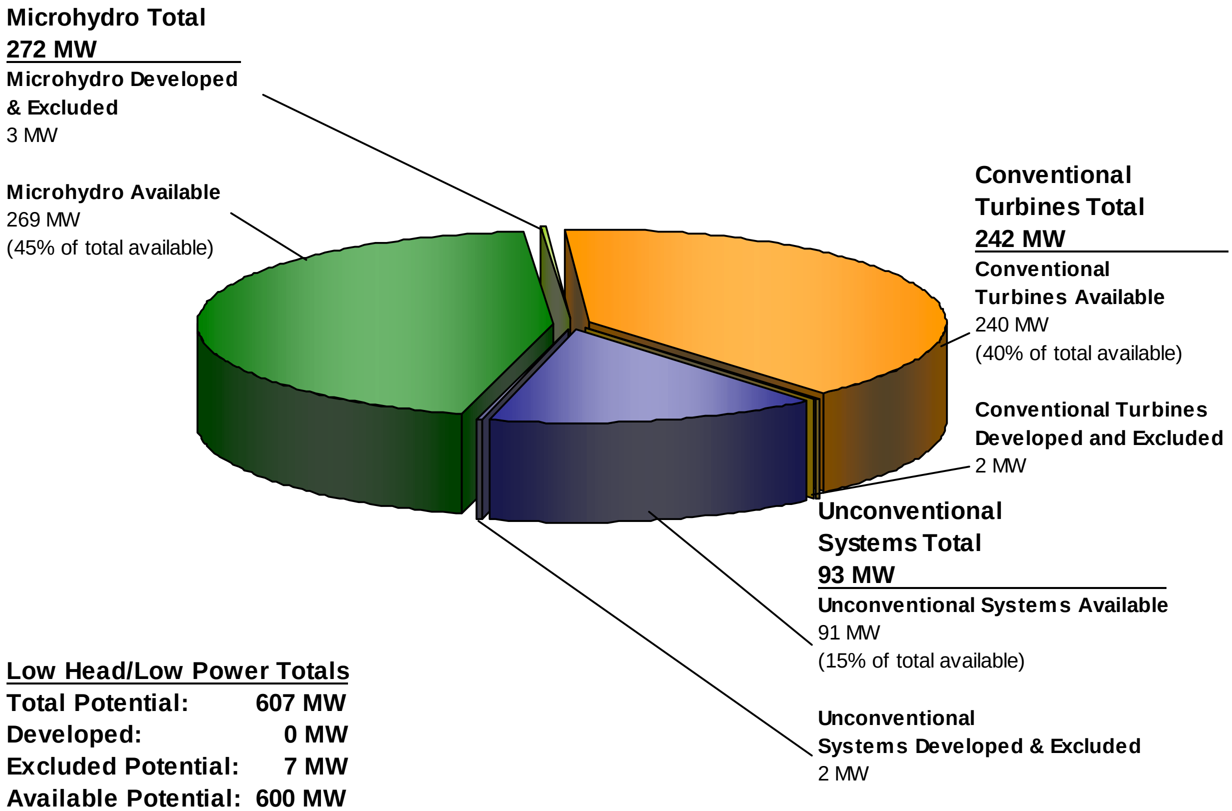


Figure B-4. Distribution of low head/low power hydropower potential in Alabama among three low head/low power hydropower technology classes.

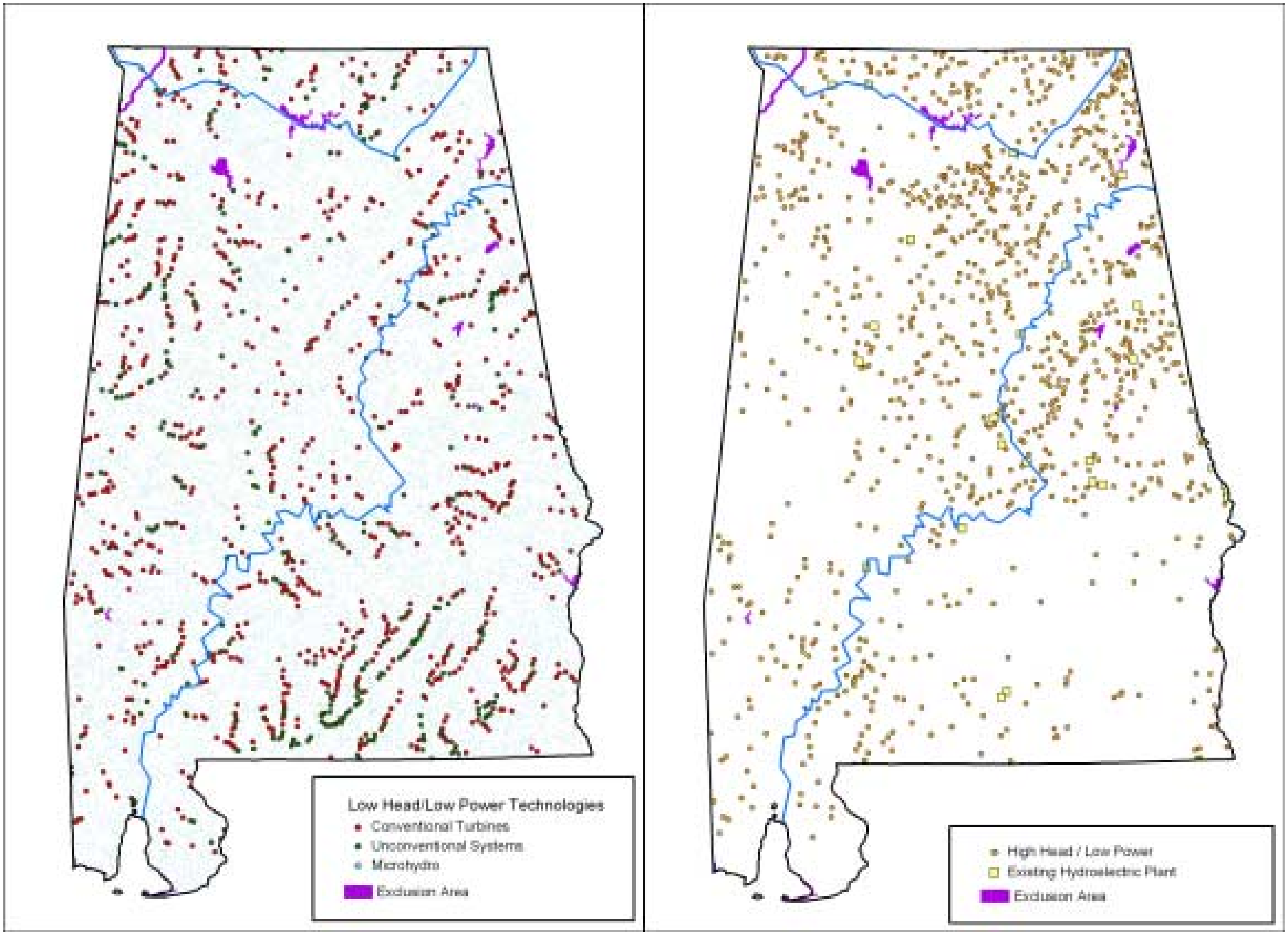


Figure B-5. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Alabama.

B.2 Arizona

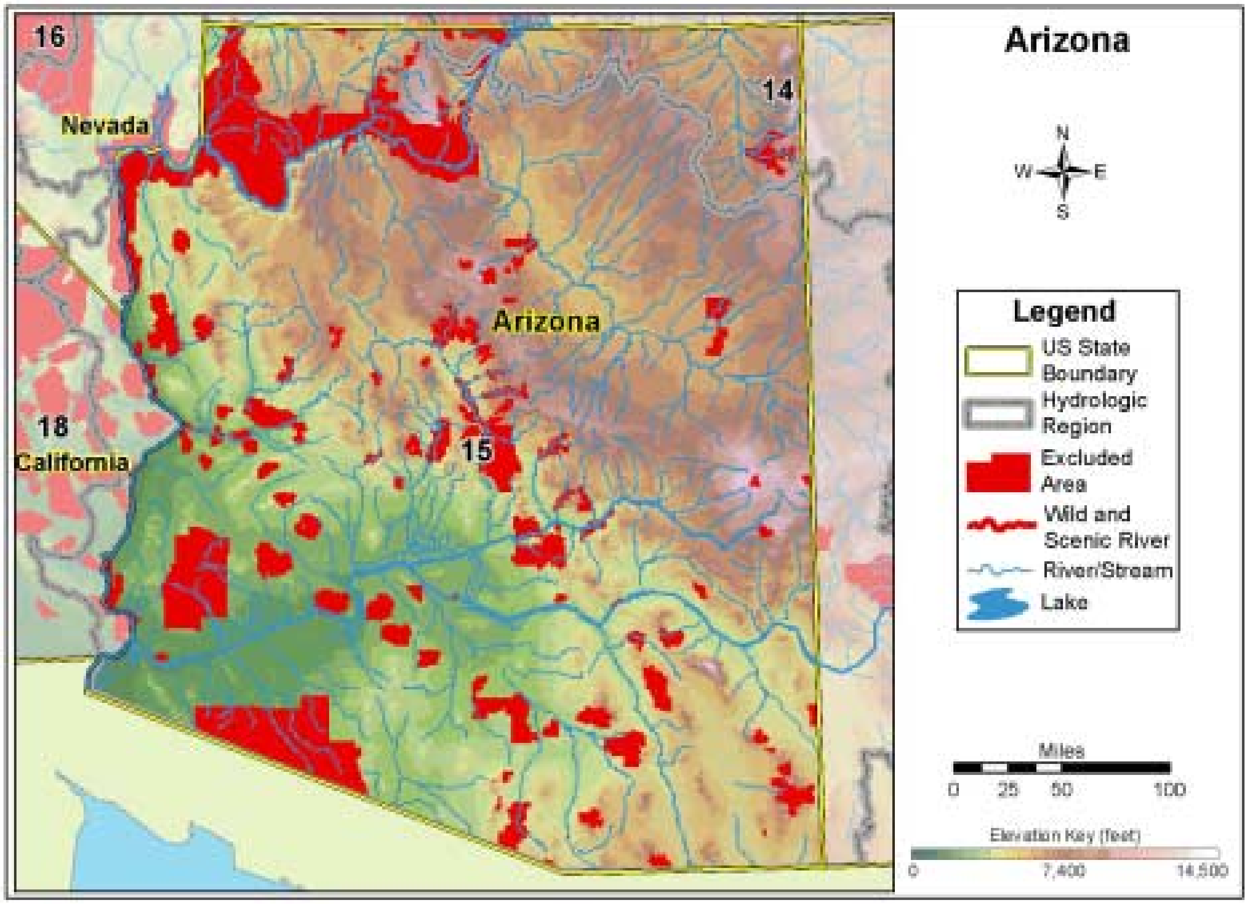


Figure B-6. Arizona.

Table B-2. Summary of results of hydropower resource assessment of Arizona.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**3,587**	**929**	**1,244**	**1,414**
TOTAL HIGH POWER	**2,396**	**929**	**986**	**481**
High Head/High Power	**1,764**	**929**	**434**	**401**
Low Head/High Power	**632**	**0**	**552**	**80**
TOTAL LOW POWER	**1,191**	**0**	**258**	**933**
High Head/Low Power	**643**	**0**	**177**	**466**
Low Head/Low Power	**548**	**0**	**81**	**467**
Conventional Turbine	171	0	17	154
Unconventional Systems	50	0	12	38
Microhydro	327	0	52	275

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

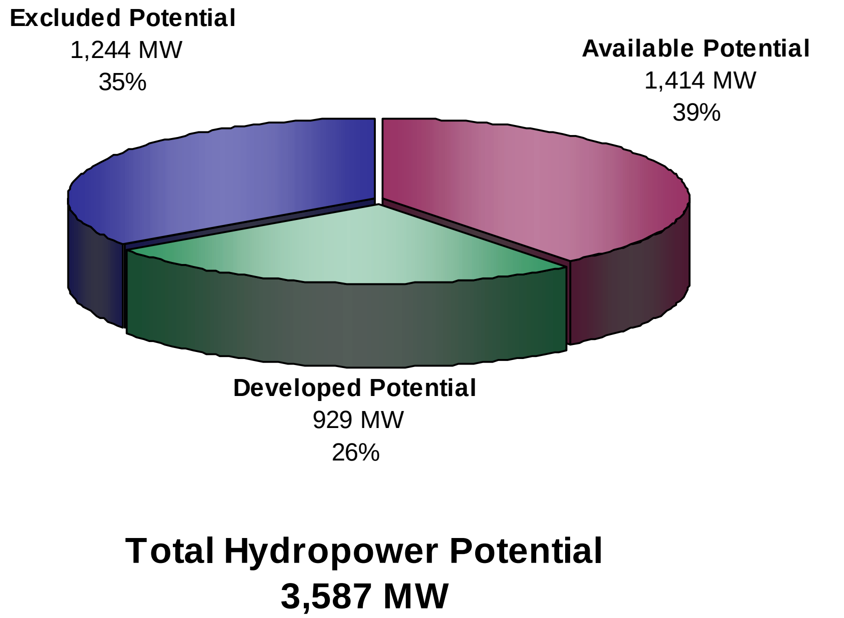


Figure B-7. Distribution of total hydropower potential in Arizona.

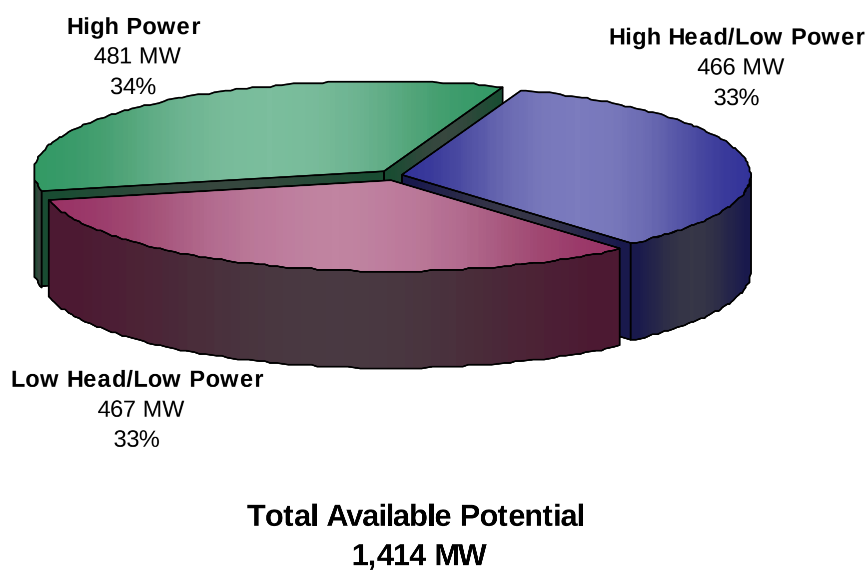


Figure B-8. Distribution of available hydropower potential in Arizona.

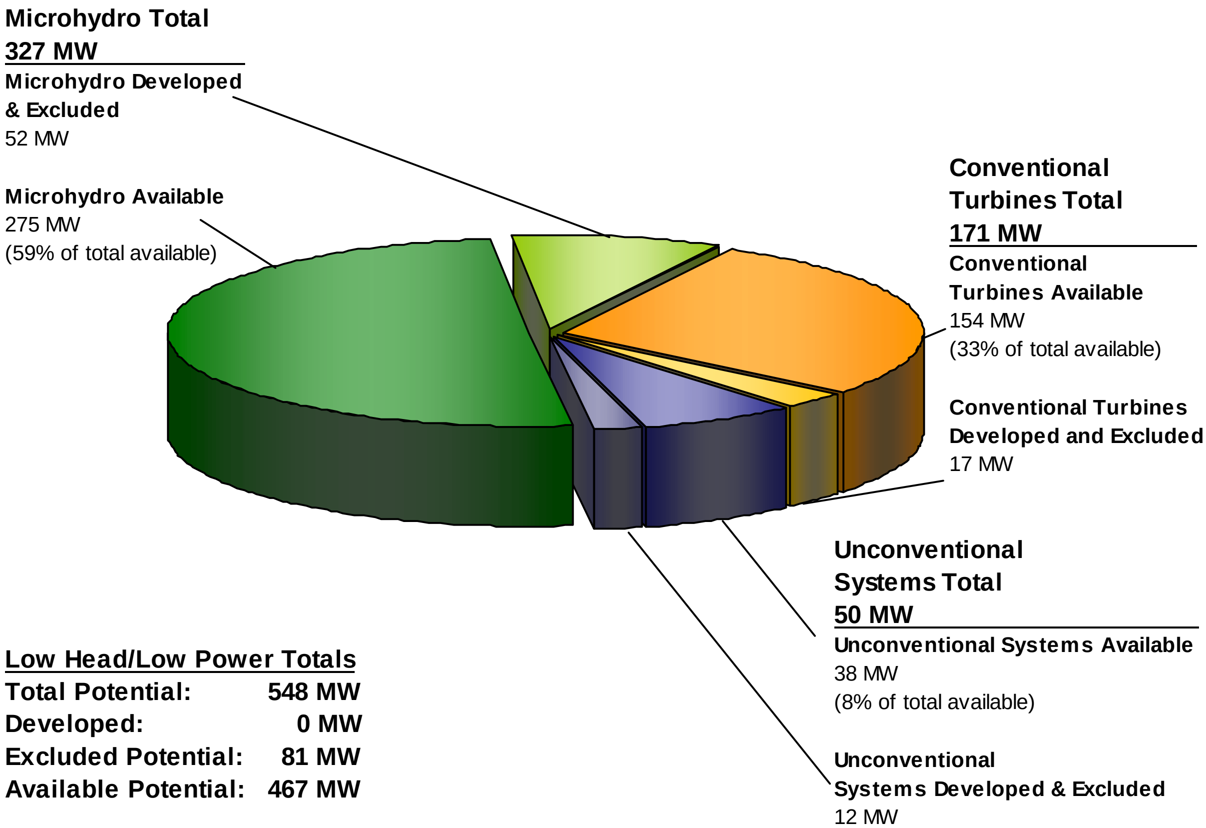


Figure B-9. Distribution of low head/low power hydropower potential in Arizona among three low head/low power hydropower technology classes.

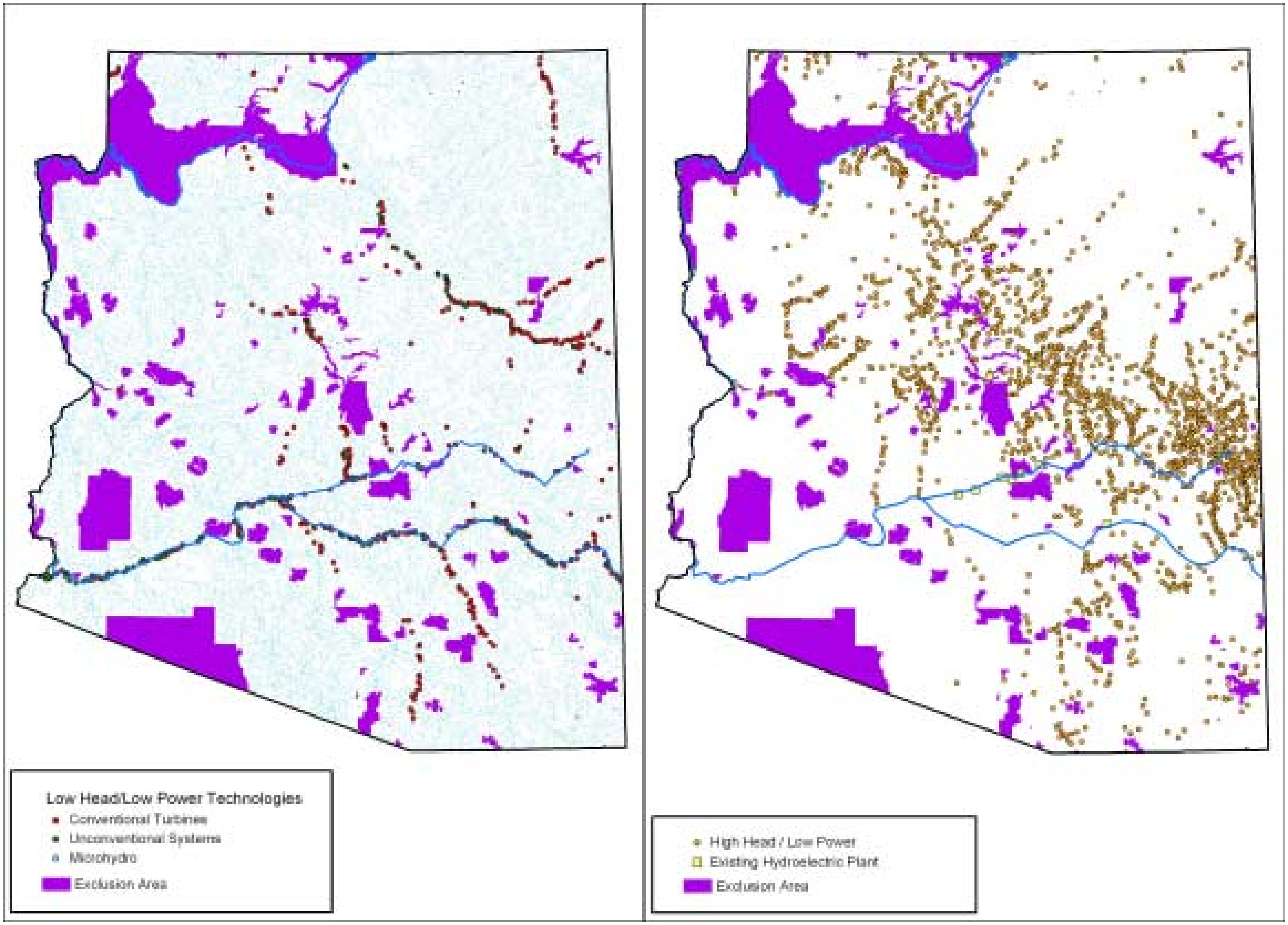


Figure B-5. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Arizona.

B.3 Arkansas

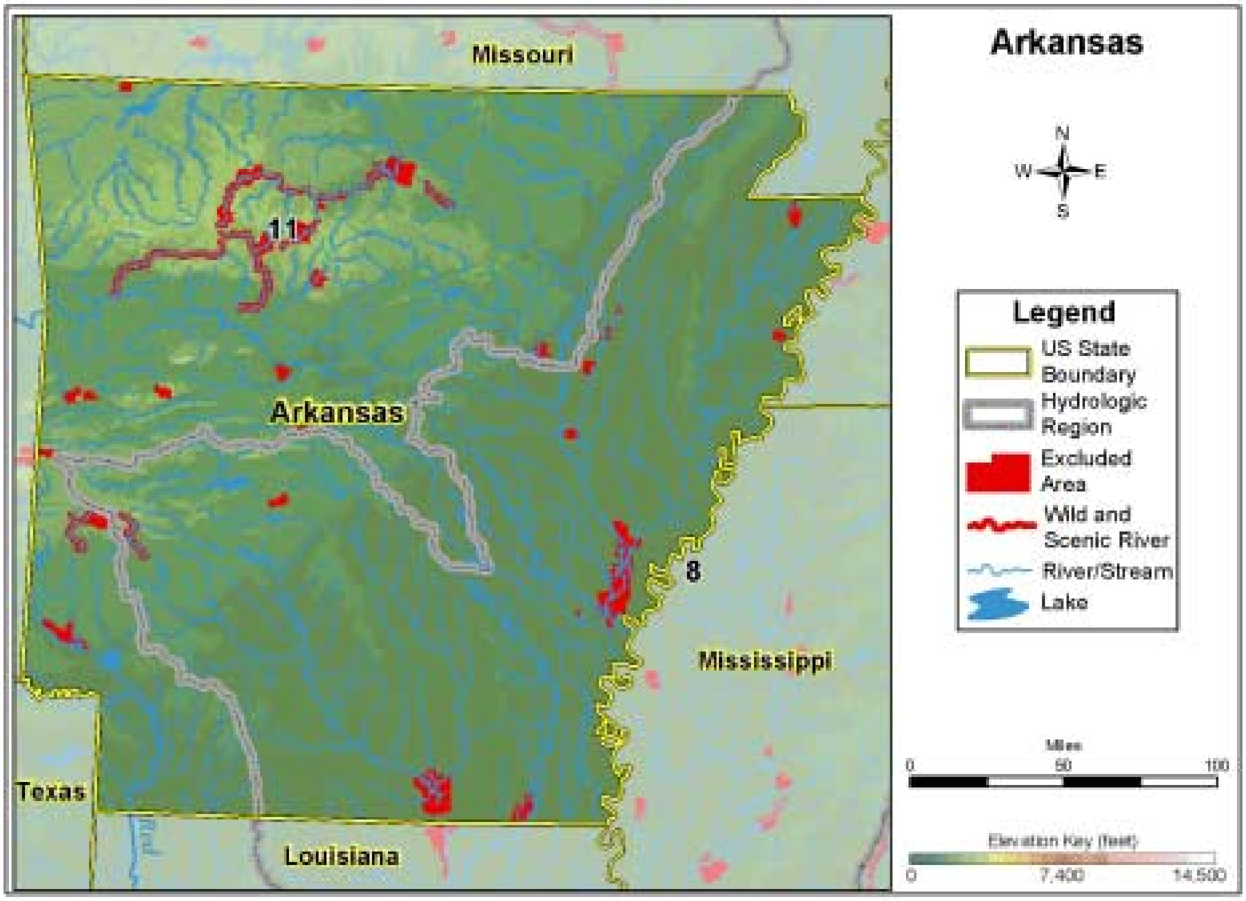


Figure B-11. Arkansas.

Table B-3. Summary of results of hydropower resource assessment of Arkansas.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**4,904**	**405**	**407**	**4,092**
TOTAL HIGH POWER	**3,999**	**405**	**314**	**3,280**
High Head/High Power	**389**	**308**	**43**	**38**
Low Head/High Power	**3,610**	**97**	**271**	**3,242**
TOTAL LOW POWER	**905**	**0**	**93**	**812**
High Head/Low Power	**380**	**0**	**56**	**324**
Low Head/Low Power	**525**	**0**	**37**	**488**
Conventional Turbine	173	0	18	155
Unconventional Systems	118	0	8	110
Microhydro	234	0	11	223

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

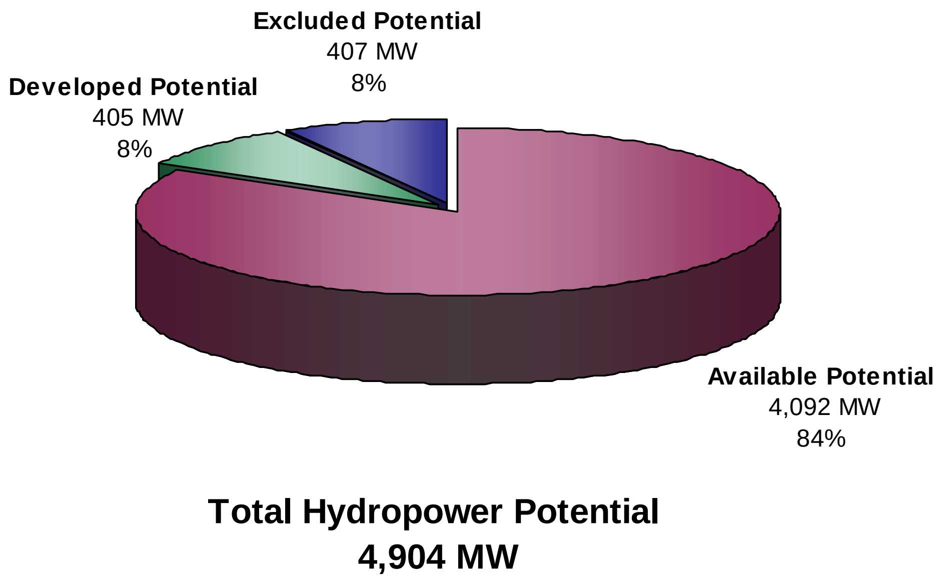


Figure B-12. Distribution of total hydropower potential in Arkansas.

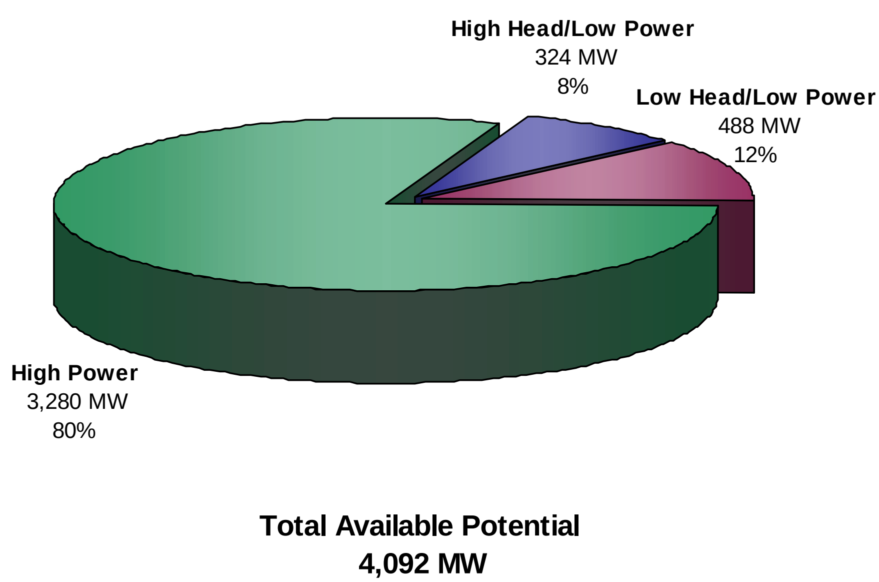


Figure B-13. Distribution of available hydropower potential in Arkansas.

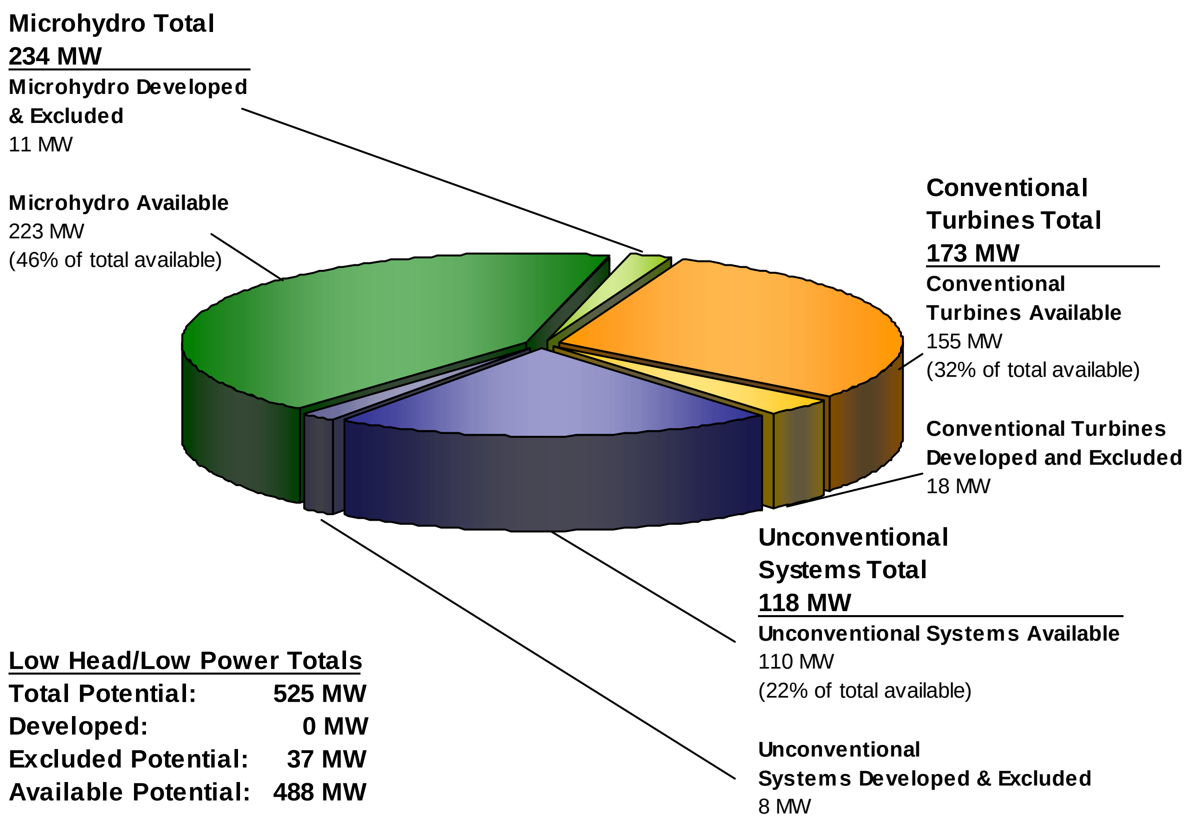


Figure B-14. Distribution of low head/low power hydropower potential in Arkansas among three low head/low power hydropower technology classes.

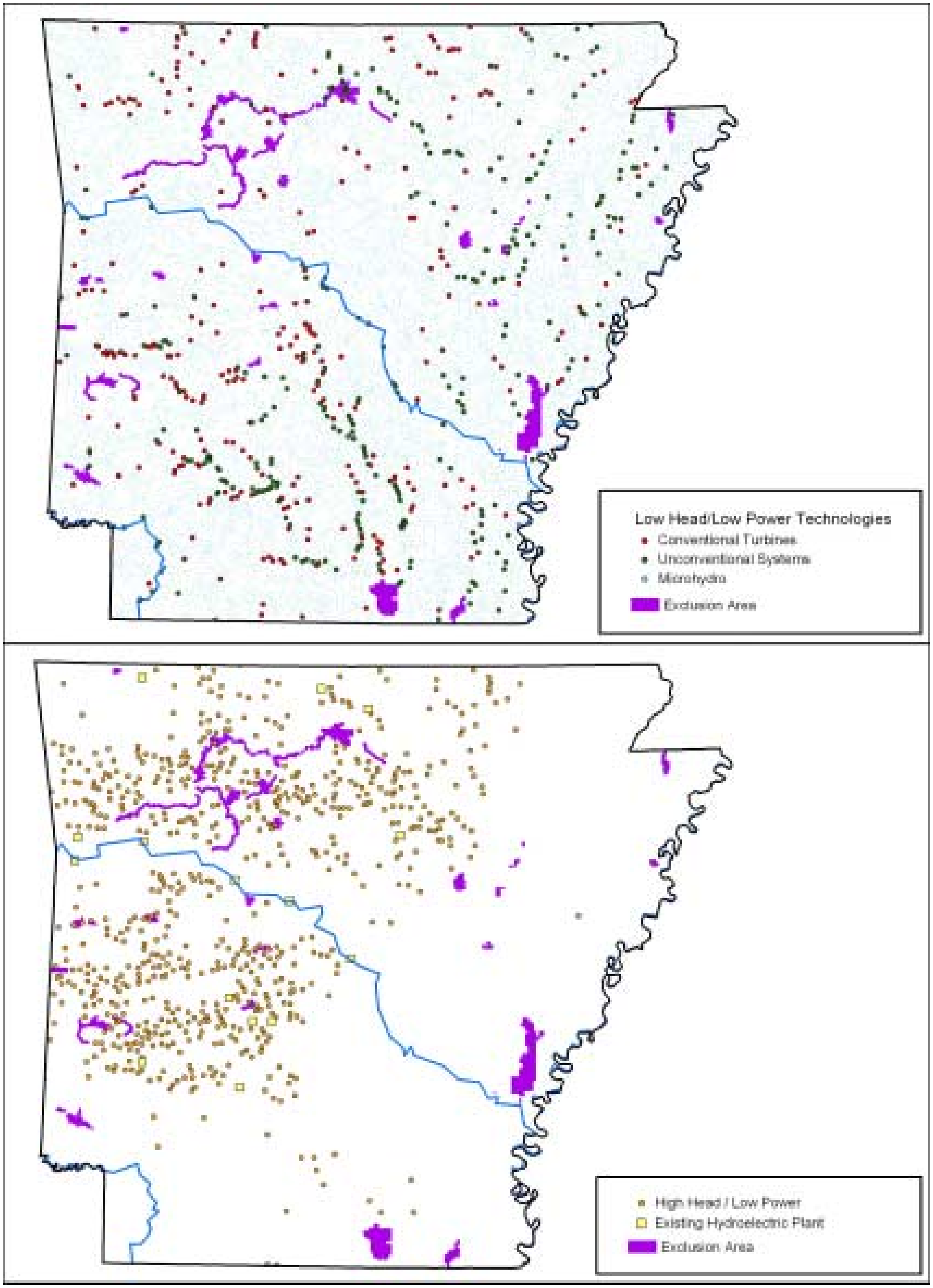


Figure B-15. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Arkansas.

B.4 California

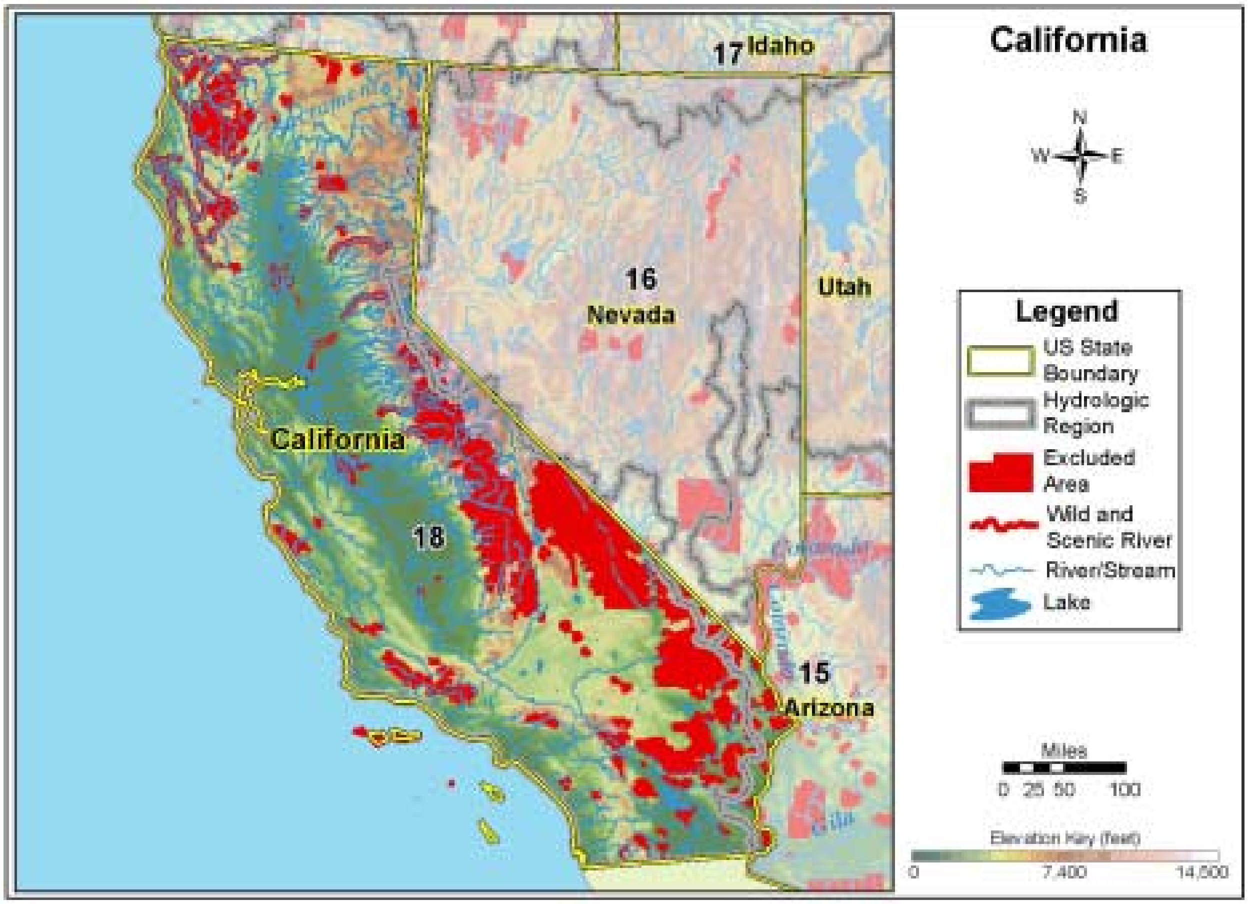


Figure B-16. California.

Table B-4. Summary of results of hydropower resource assessment of California.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**26,638**	**4,705**	**11,628**	**10,305**
TOTAL HIGH POWER	**22,920**	**4,678**	**10,505**	**7,737**
High Head/High Power	**21,366**	**4,652**	**9,469**	**7,245**
Low Head/High Power	**1,554**	**26**	**1,036**	**492**
TOTAL LOW POWER	**3,718**	**27**	**1,123**	**2,568**
High Head/Low Power	**2,934**	**23**	**970**	**1,941**
Low Head/Low Power	**784**	**4**	**153**	**627**
Conventional Turbine	235	2	36	197
Unconventional Systems	101	1	24	76
Microhydro	448	1	93	354

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

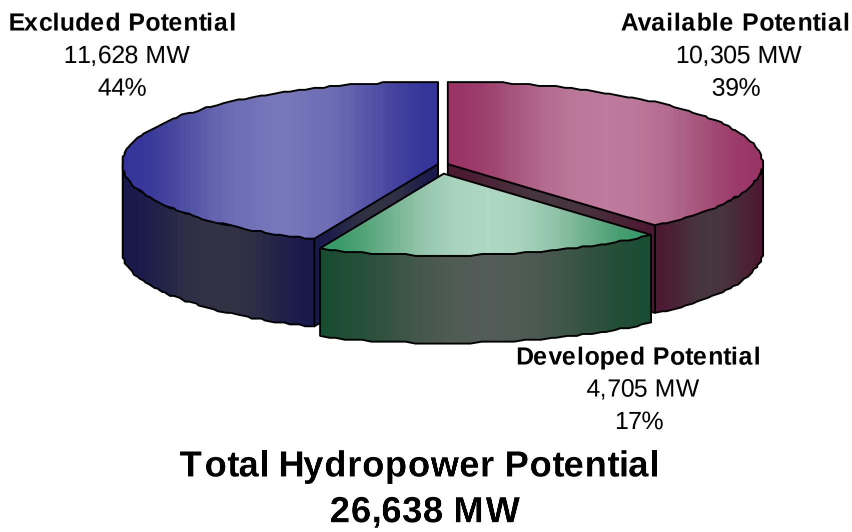


Figure B-17. Distribution of total hydropower potential in California.

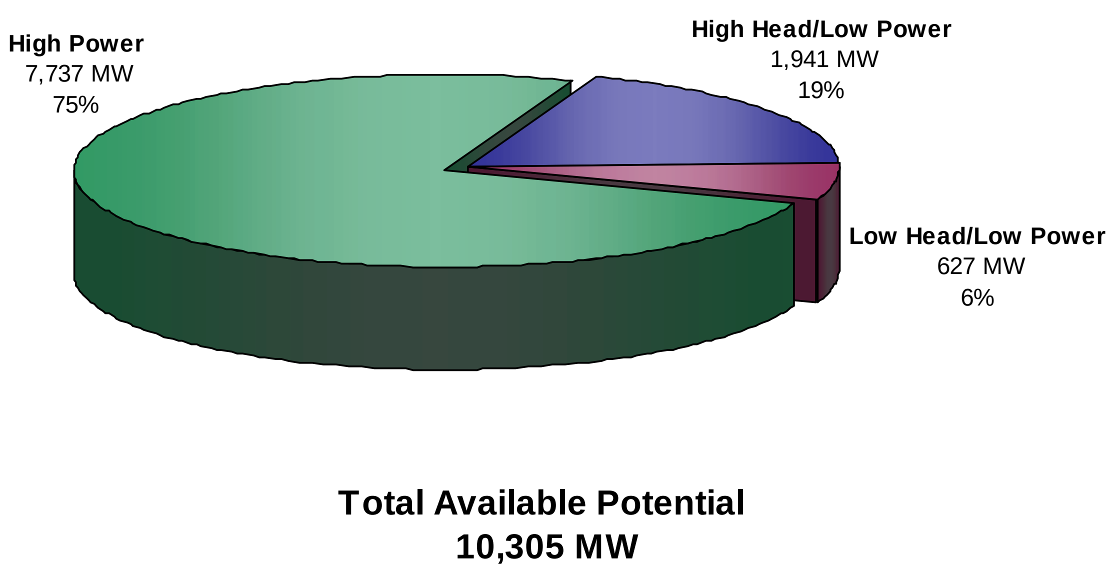


Figure B-18. Distribution of available hydropower potential in California.

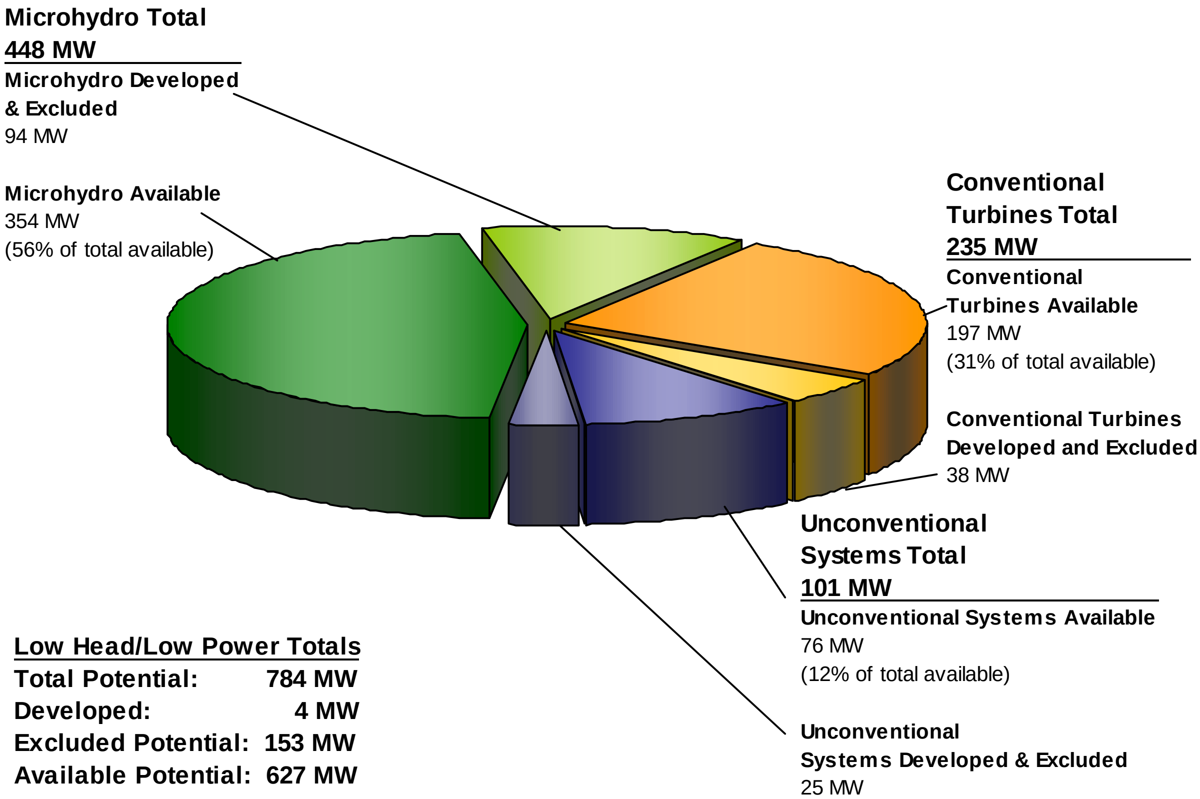


Figure B-19. Distribution of low head/low power hydropower potential in California among three low head/low power hydropower technology classes.

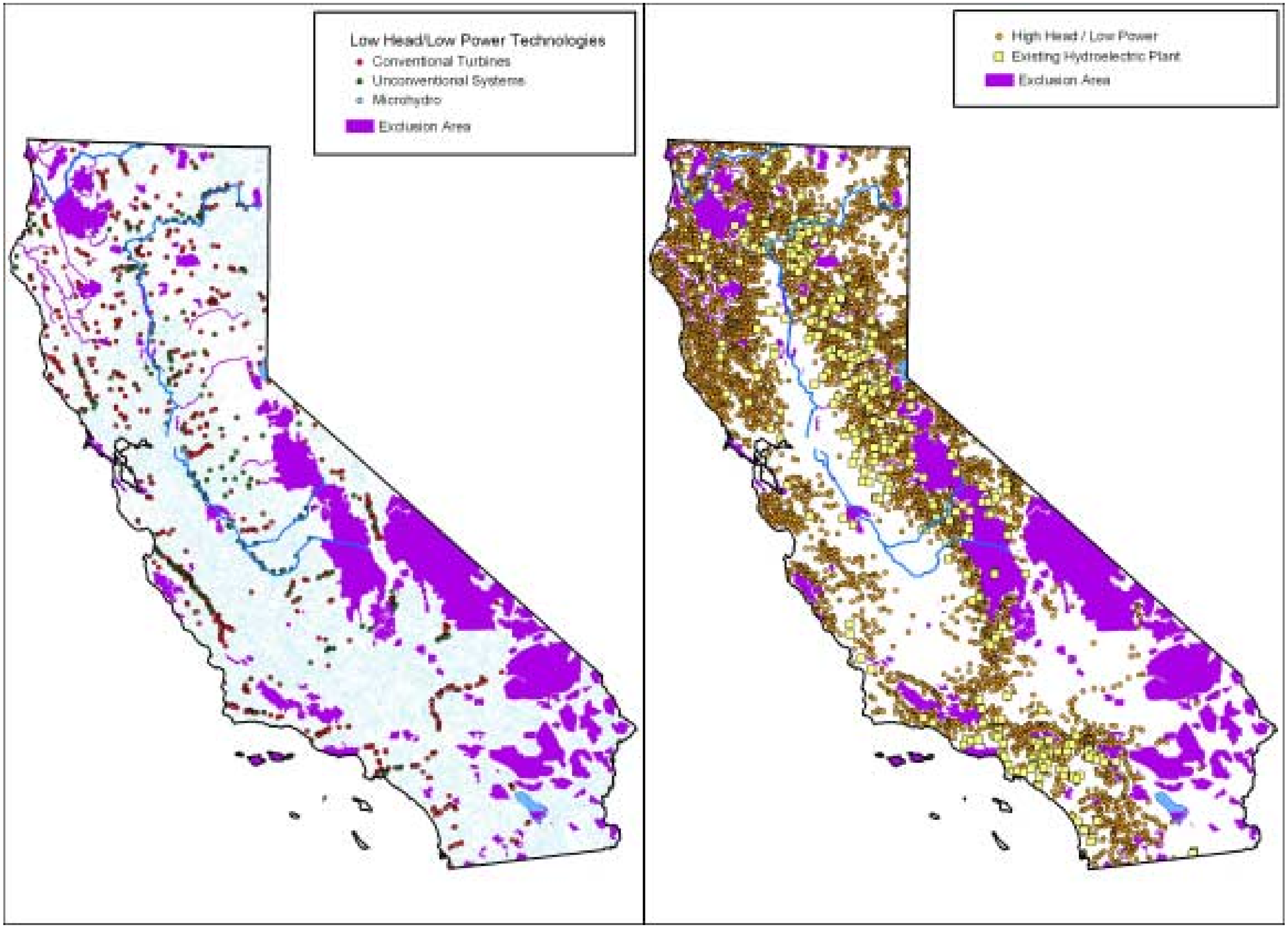


Figure B-20. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in California.

B.5 Colorado

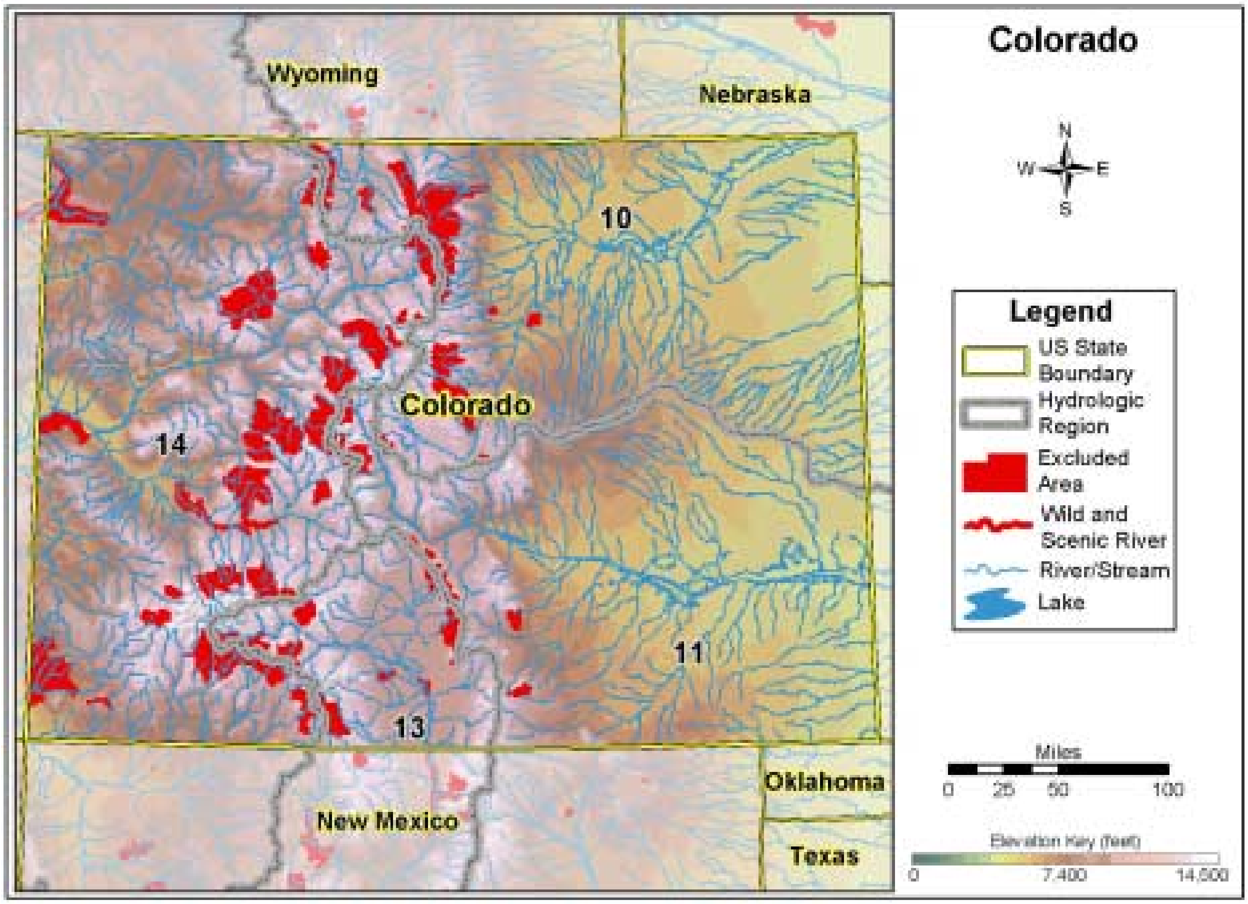


Figure B-21. Colorado.

Table B-5. Summary of results of hydropower resource assessment of Colorado.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**7,413**	**246**	**2,275**	**4,892**
TOTAL HIGH POWER	**4,940**	**240**	**1,726**	**2,974**
High Head/High Power	**4,411**	**240**	**1,664**	**2,507**
Low Head/High Power	**529**	**0**	**62**	**467**
TOTAL LOW POWER	**2,473**	**6**	**549**	**1,918**
High Head/Low Power	**1,844**	**6**	**505**	**1,333**
Low Head/Low Power	**629**	**0**	**44**	**585**
Conventional Turbine	249	0	10	239
Unconventional Systems	65	0	6	59
Microhydro	315	0	28	287

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

Colorado

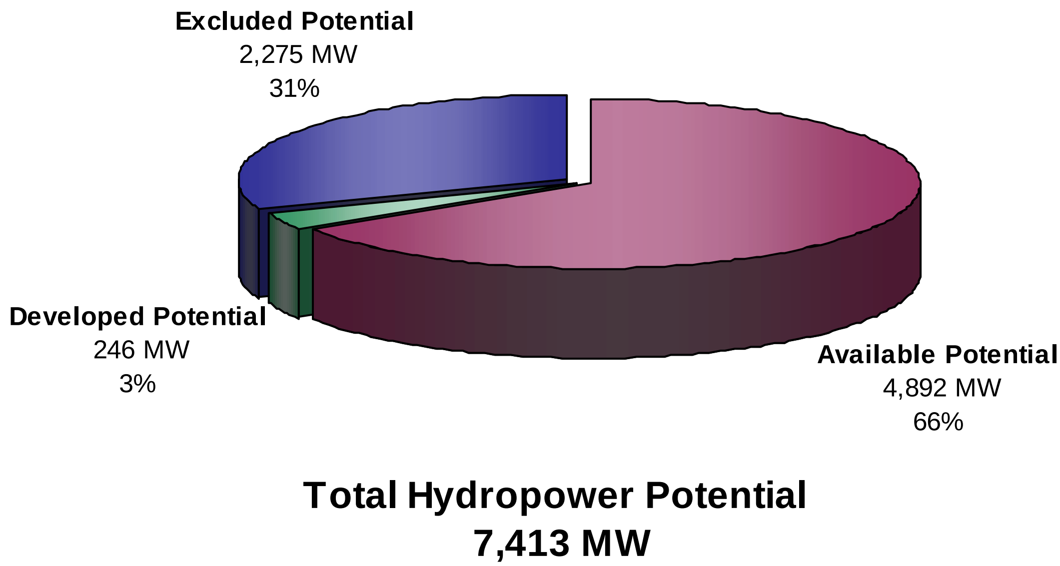


Figure B-22. Distribution of total hydropower potential in Colorado.

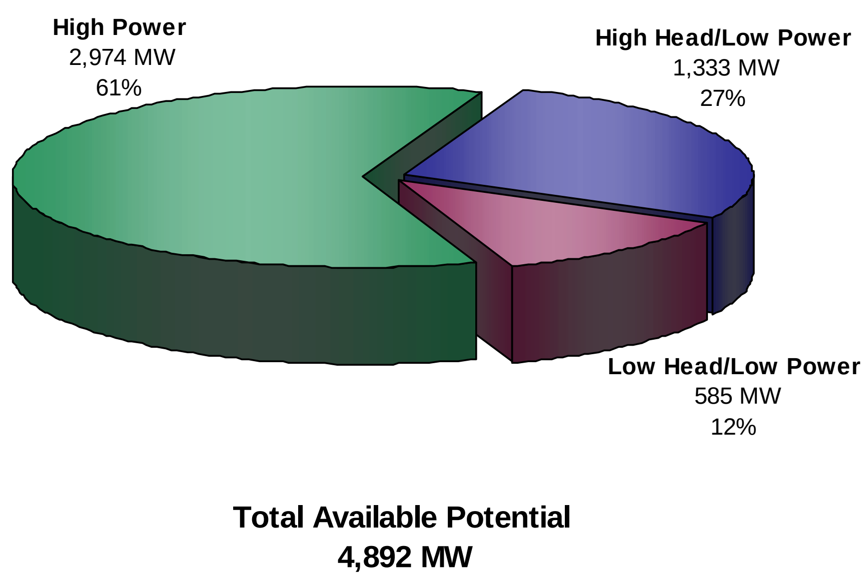


Figure B-23. Distribution of available hydropower potential in Colorado.

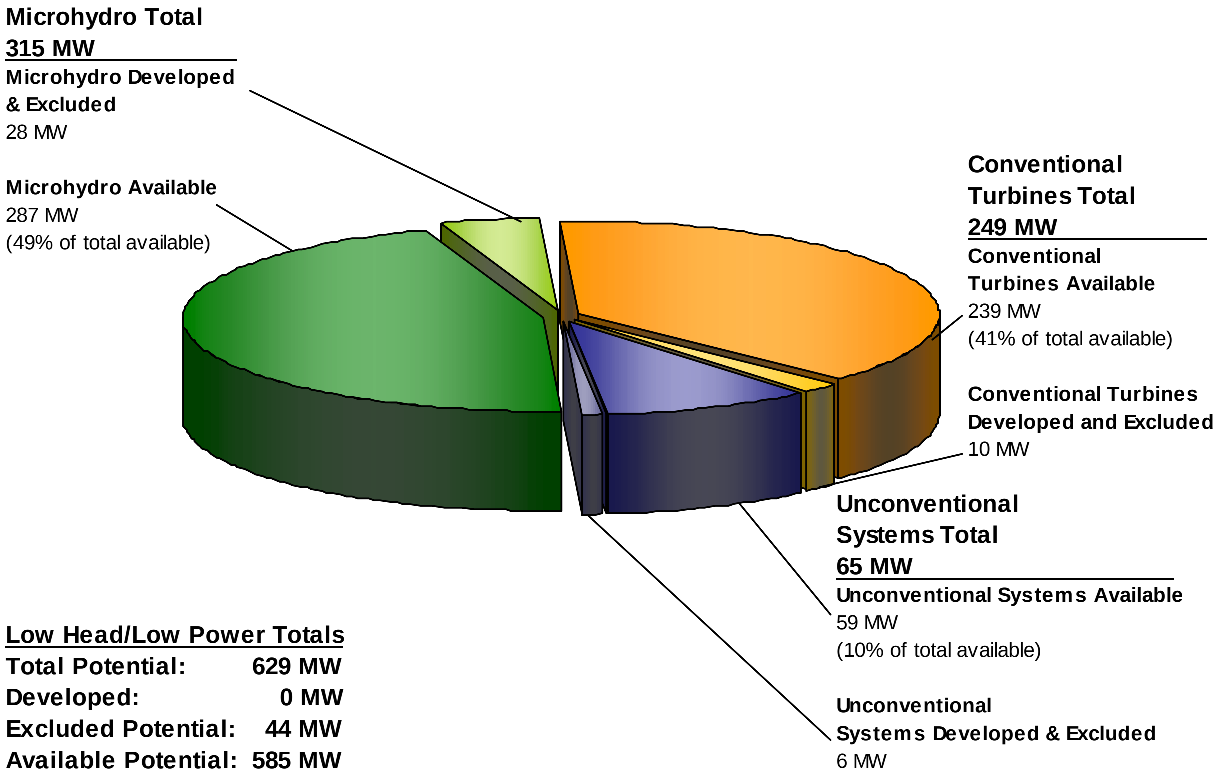
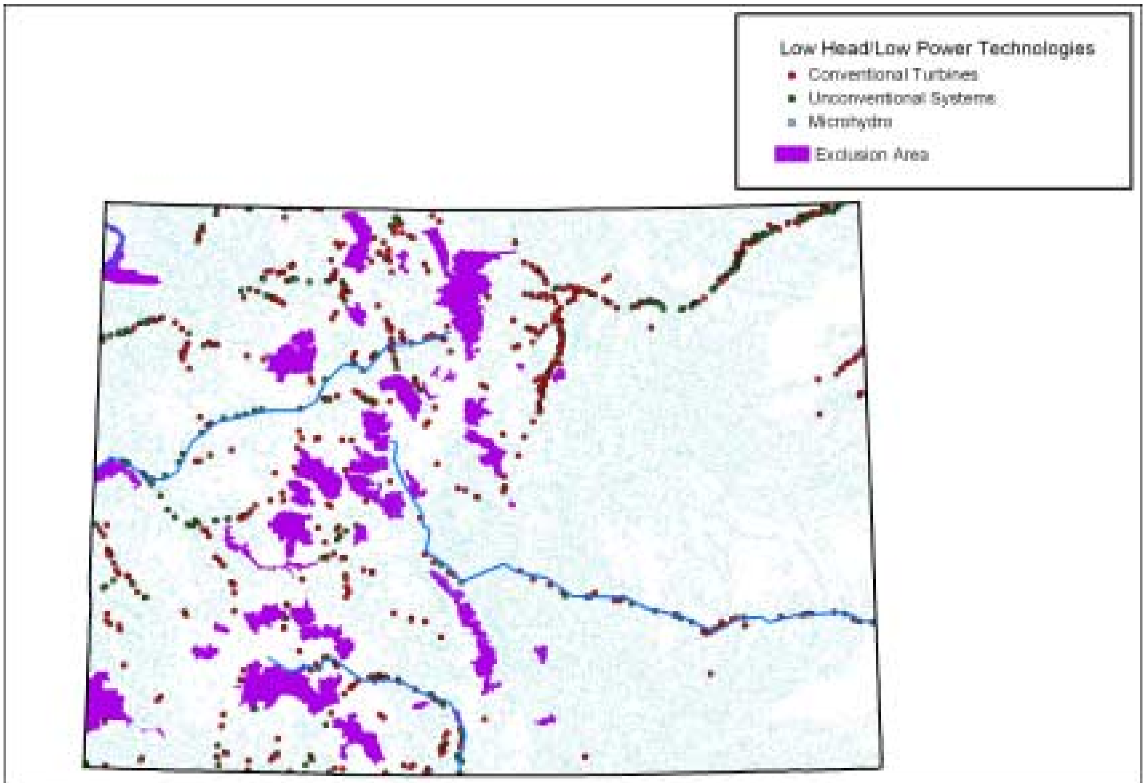


Figure B-24. Distribution of low head/low power hydropower potential in Colorado among three low head/low power hydropower technology classes.



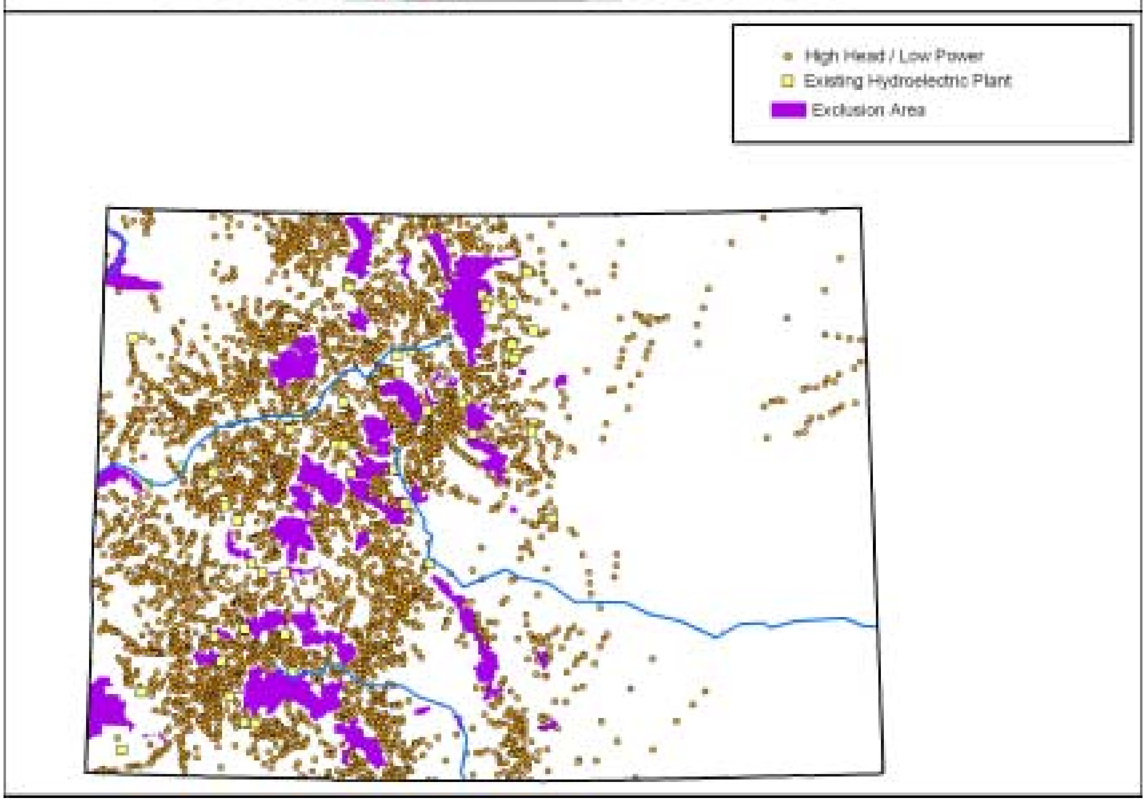


Figure B-25. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Colorado.

B.6 Connecticut

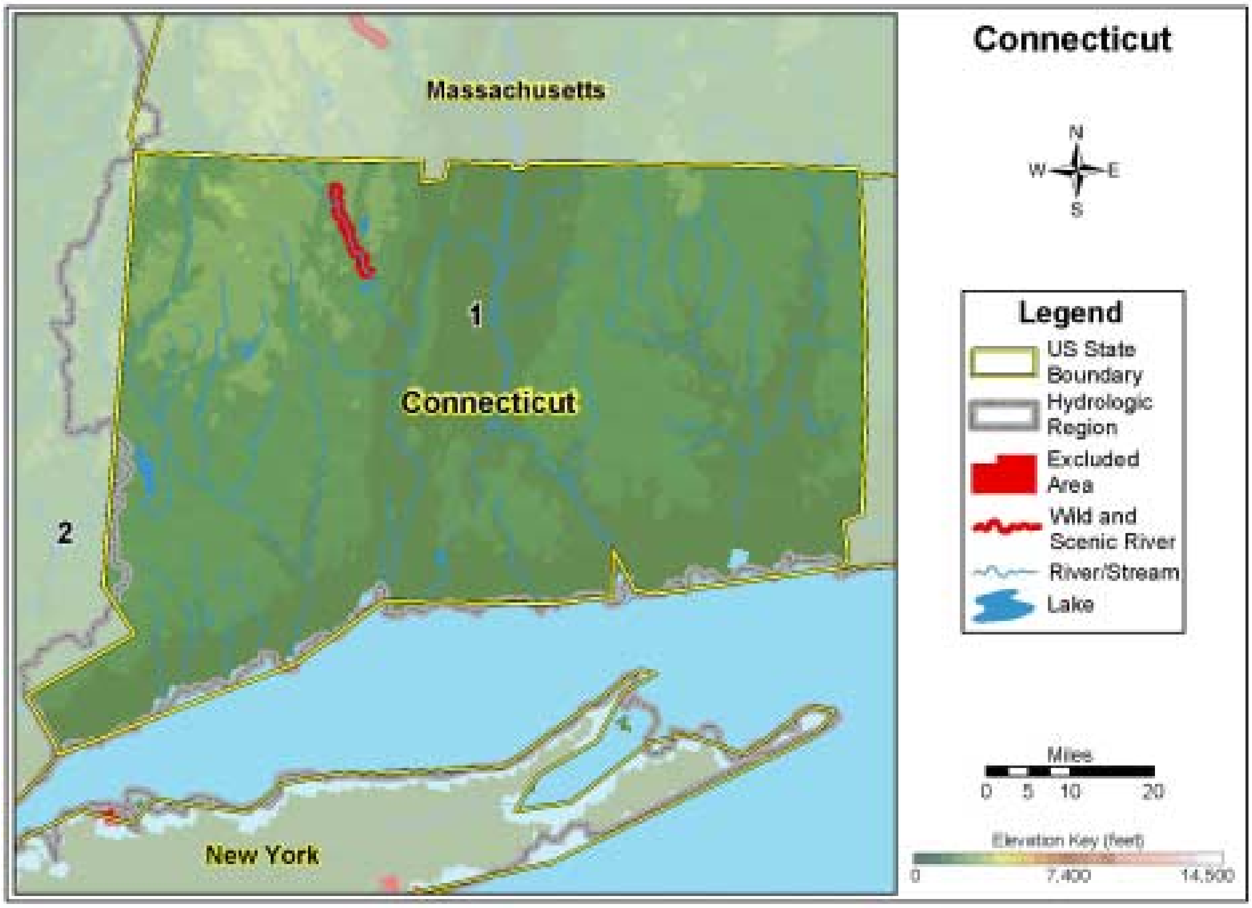


Figure B-26. Connecticut.

Table B-6. Summary of results of hydropower resource assessment of Connecticut.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**432**	**55**	**18**	**359**
TOTAL HIGH POWER	**273**	**51**	**16**	**206**
High Head/High Power	**148**	**43**	**15**	**90**
Low Head/High Power	**125**	**8**	**1**	**116**
TOTAL LOW POWER	**159**	**4**	**2**	**153**
High Head/Low Power	**105**	**1**	**2**	**102**
Low Head/Low Power	**54**	**3**	**0**	**51**
Conventional Turbine	18	3	0	15
Unconventional Systems	11	0	0	11
Microhydro	25	0	0	25

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

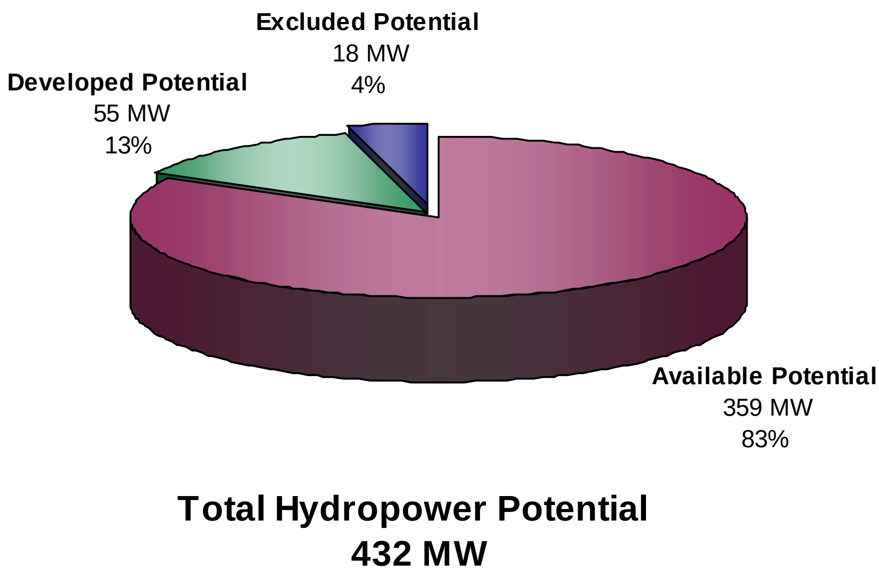


Figure B-27. Distribution of total hydropower potential in Connecticut.

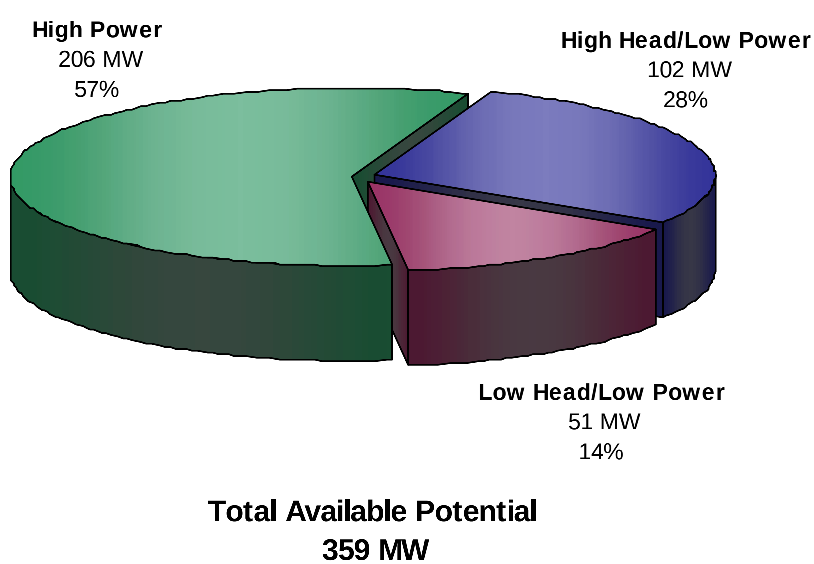


Figure B-28. Distribution of available hydropower potential in Connecticut.

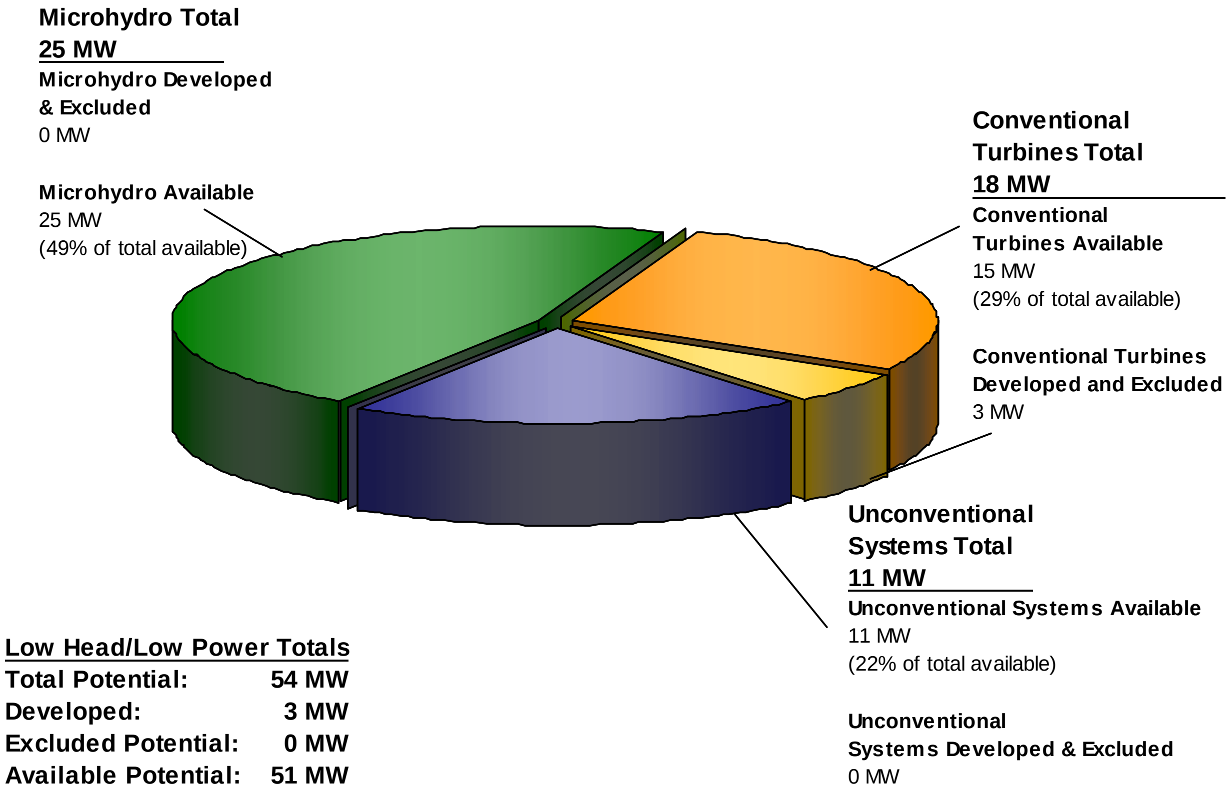


Figure B-29. Distribution of low head/low power hydropower potential in Connecticut among three low head/low power hydropower technology classes.

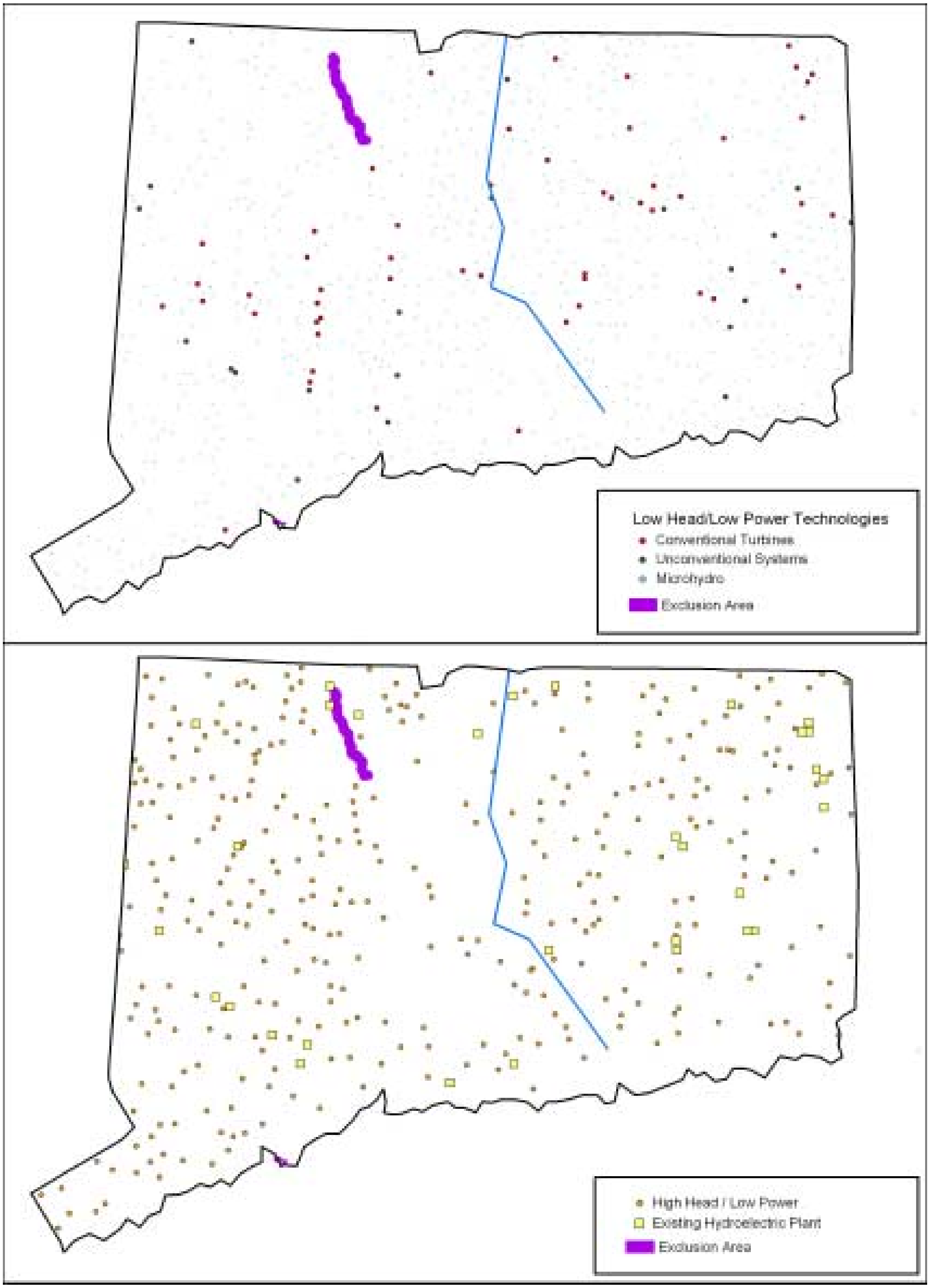


Figure B-30. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Connecticut.

B.7 Delaware

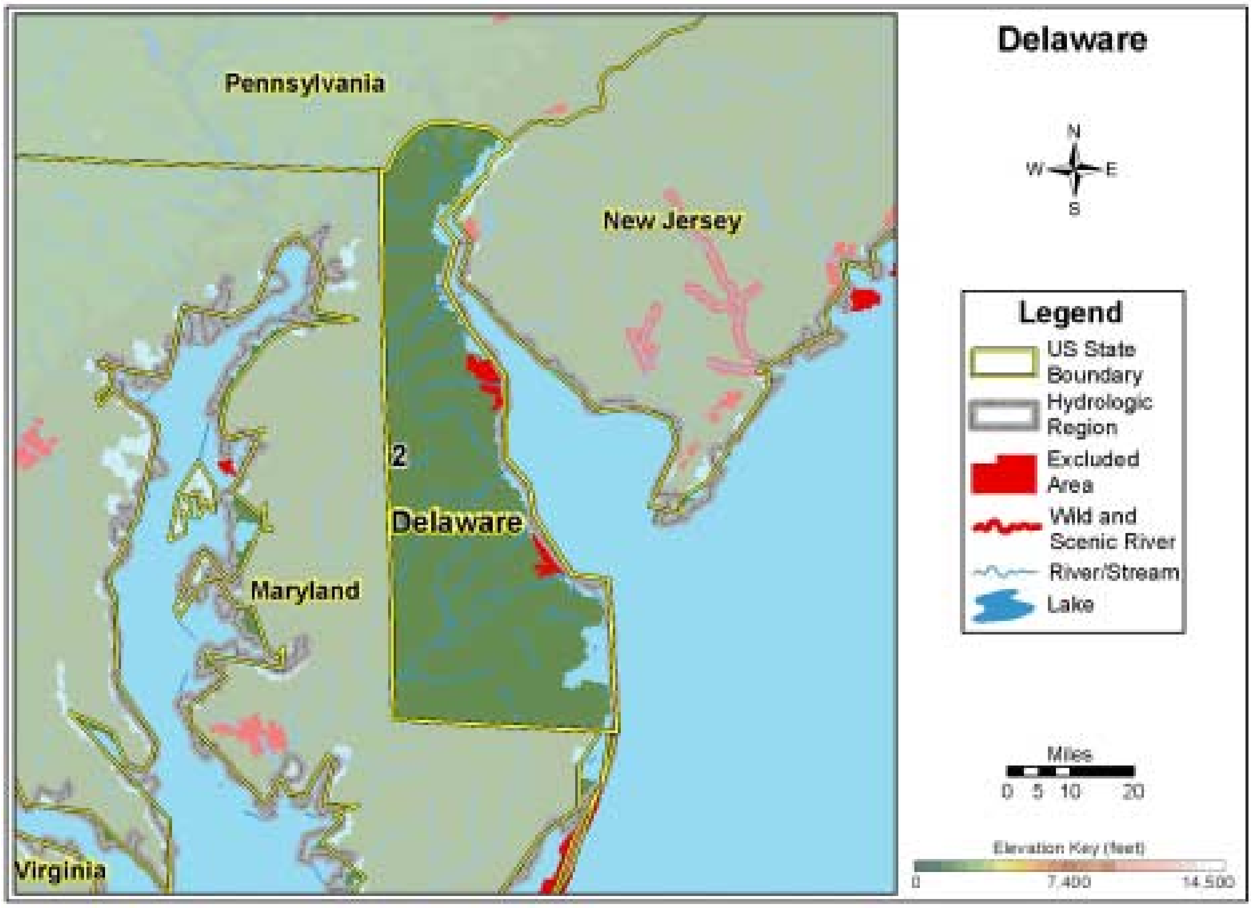


Figure B-31. Delaware.

Table B-7. Summary of results of hydropower resource assessment of Delaware.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**24**	**0**	**0**	**24**
TOTAL HIGH POWER	**15**	**0**	**0**	**15**
High Head/High Power	**5**	**0**	**0**	**5**
Low Head/High Power	**10**	**0**	**0**	**10**
TOTAL LOW POWER	**9**	**0**	**0**	**9**
High Head/Low Power	**2**	**0**	**0**	**2**
Low Head/Low Power	**7**	**0**	**0**	**7**
Conventional Turbine	1	0	0	1
Unconventional Systems	2	0	0	2
Microhydro	4	0	0	4

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

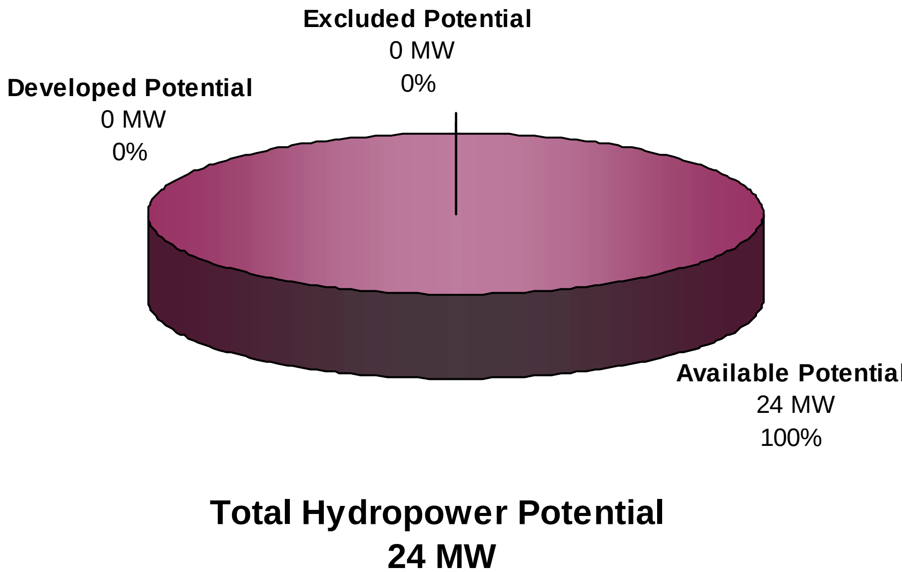


Figure B-32. Distribution of total hydropower potential in Delaware.

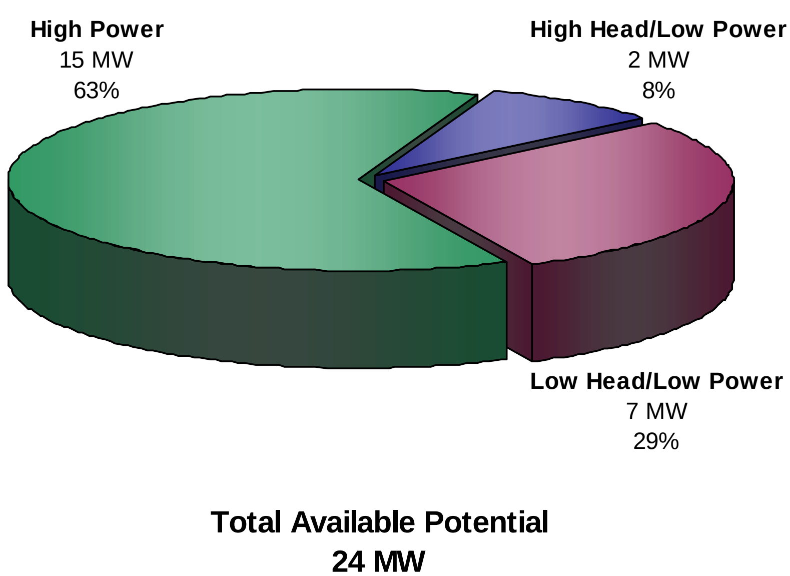


Figure B-33. Distribution of available hydropower potential in Delaware.

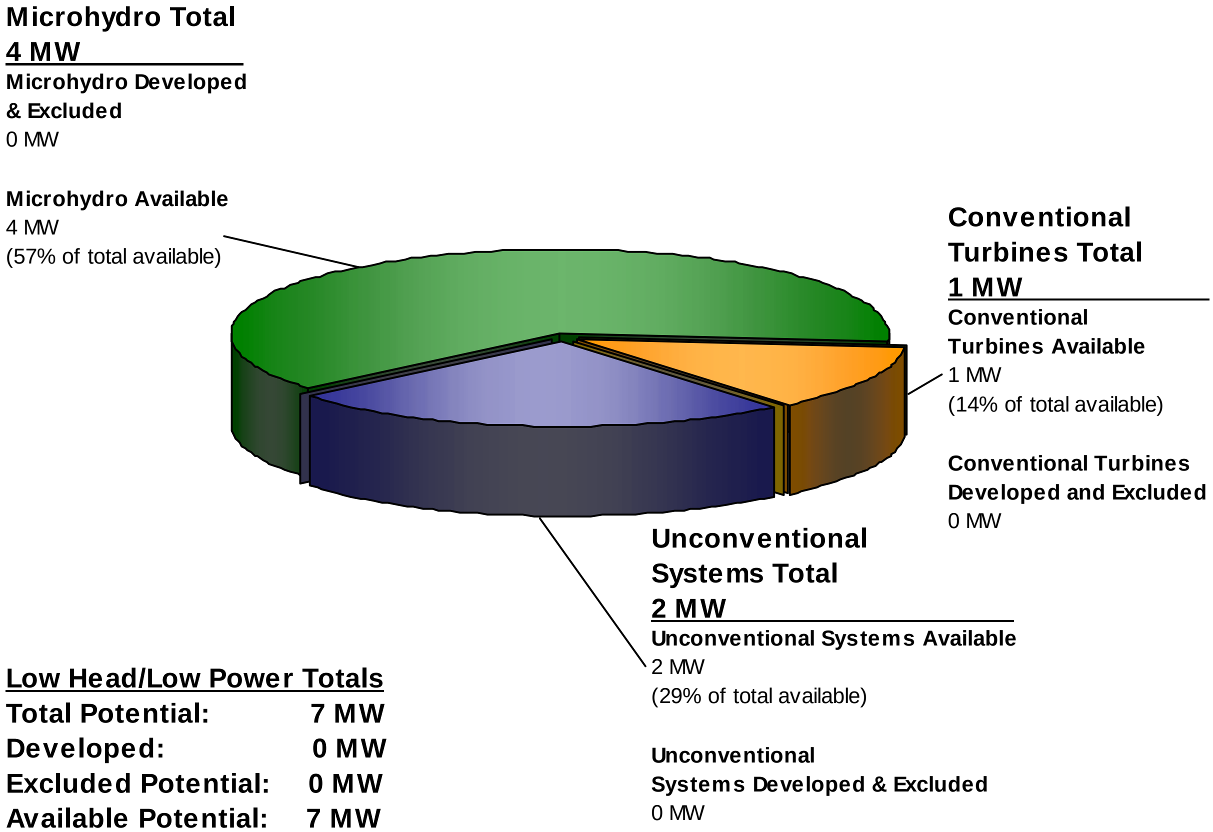


Figure B-34. Distribution of low head/low power hydropower potential in Delaware among three low head/low power hydropower technology classes.

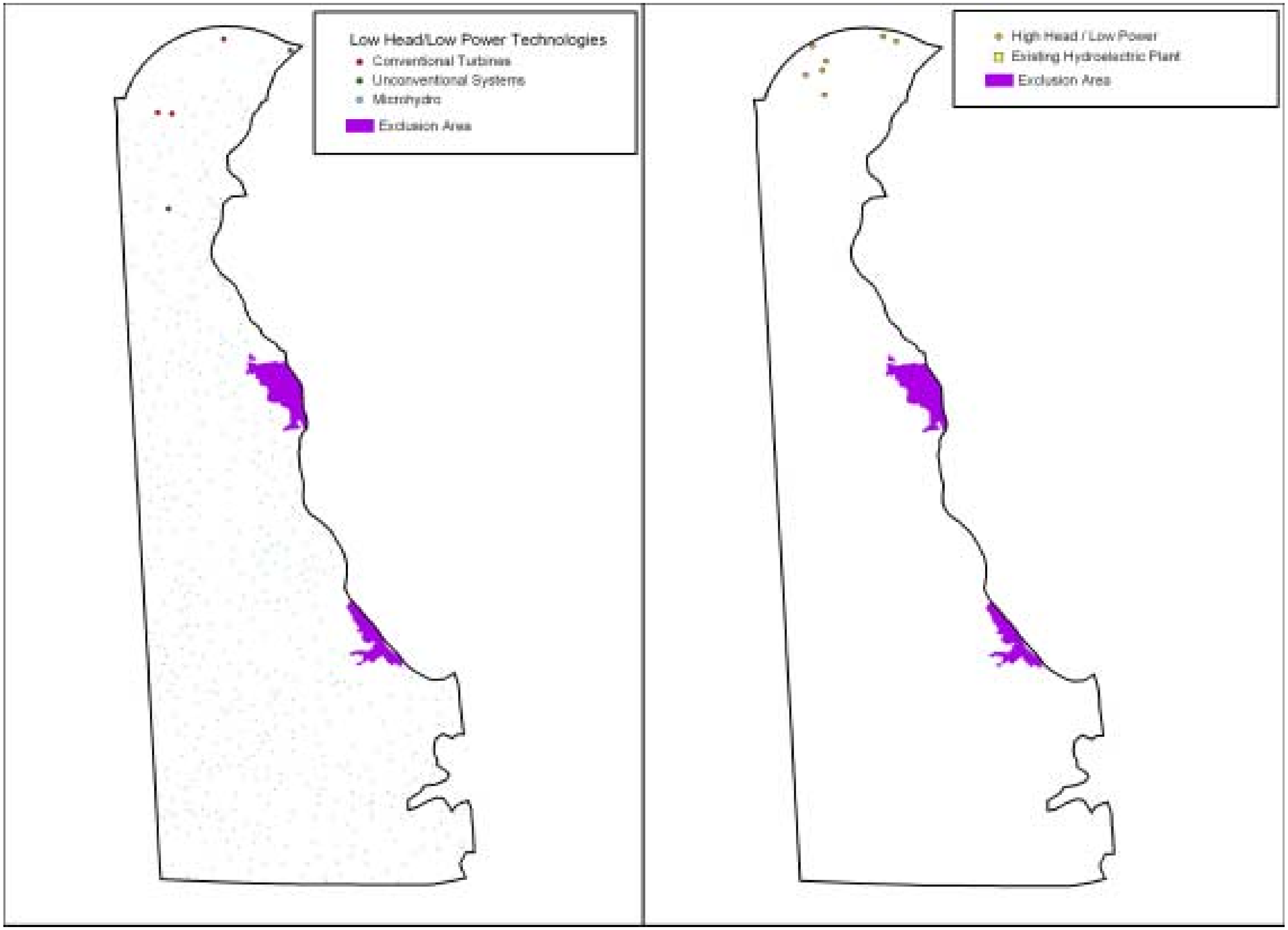


Figure B-35. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Delaware.

B.8 Florida

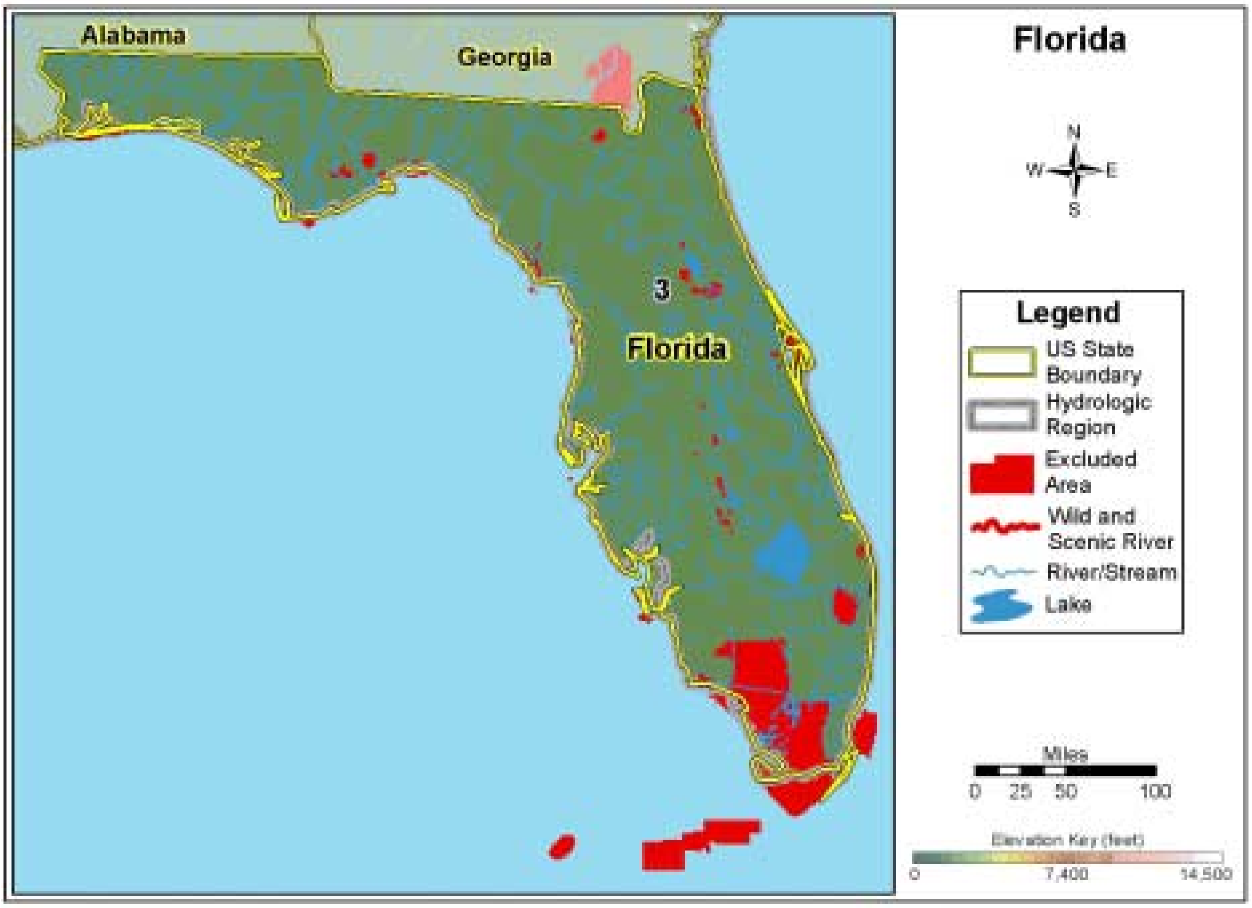


Figure B-36. Florida.

Table B-8. Summary of results of hydropower resource assessment of Florida.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**446**	**32**	**14**	**408**
TOTAL HIGH POWER	**214**	**32**	**6**	**184**
High Head/High Power	**24**	**32**	**0**	**—**
Low Head/High Power	**190**	**0**	**6**	**184**
TOTAL LOW POWER	**232**	**0**	**8**	**224**
High Head/Low Power	**13**	**0**	**0**	**13**
Low Head/Low Power	**219**	**0**	**8**	**211**
Conventional Turbine	43	0	2	41
Unconventional Systems	74	0	4	70
Microhydro	102	0	2	100

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

Note: Available high head/high power potential was negative possibly due to over-estimation of developed potential. The available high head/high power value is considered unreasonable and is not included in the power class rollup. The total power and total high power available values are rolled up values that do not match the value obtained by horizontal summing of power category values.

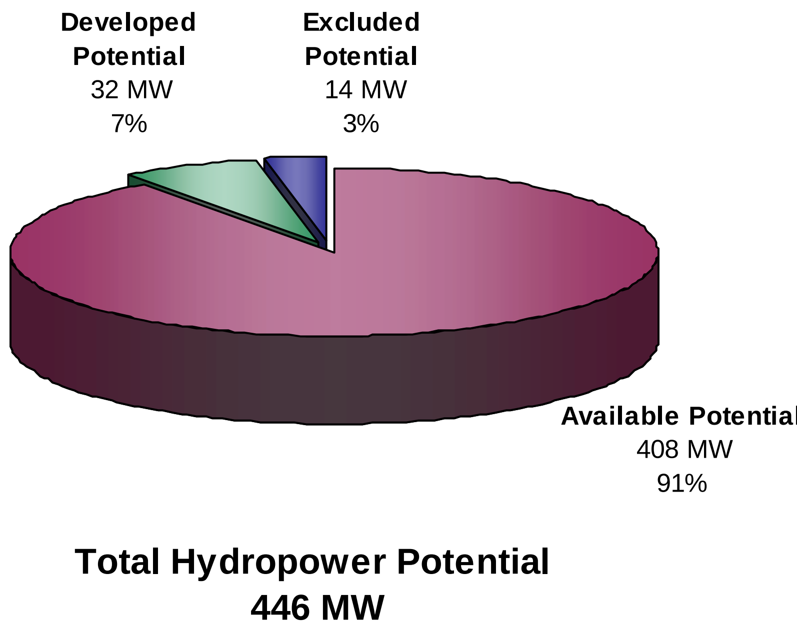


Figure B-37. Distribution of total hydropower potential in Florida.

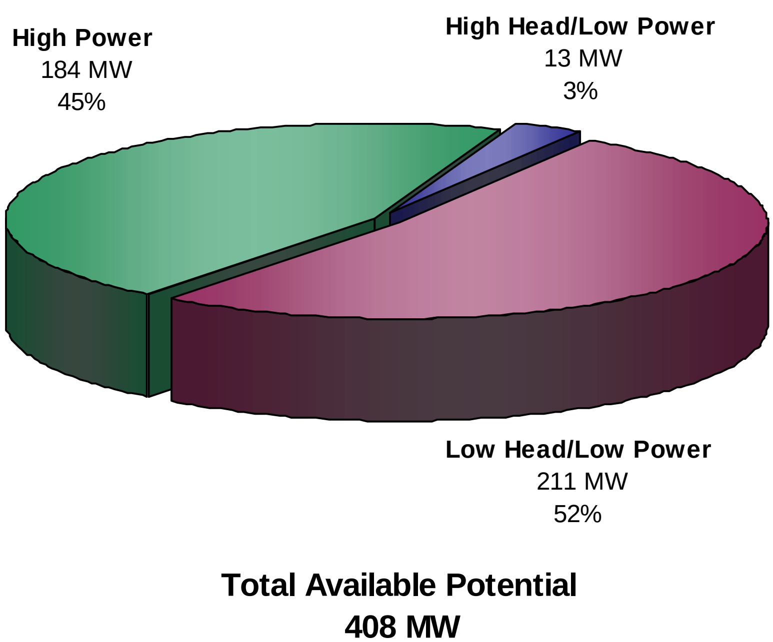


Figure B-38. Distribution of available hydropower potential in Florida.

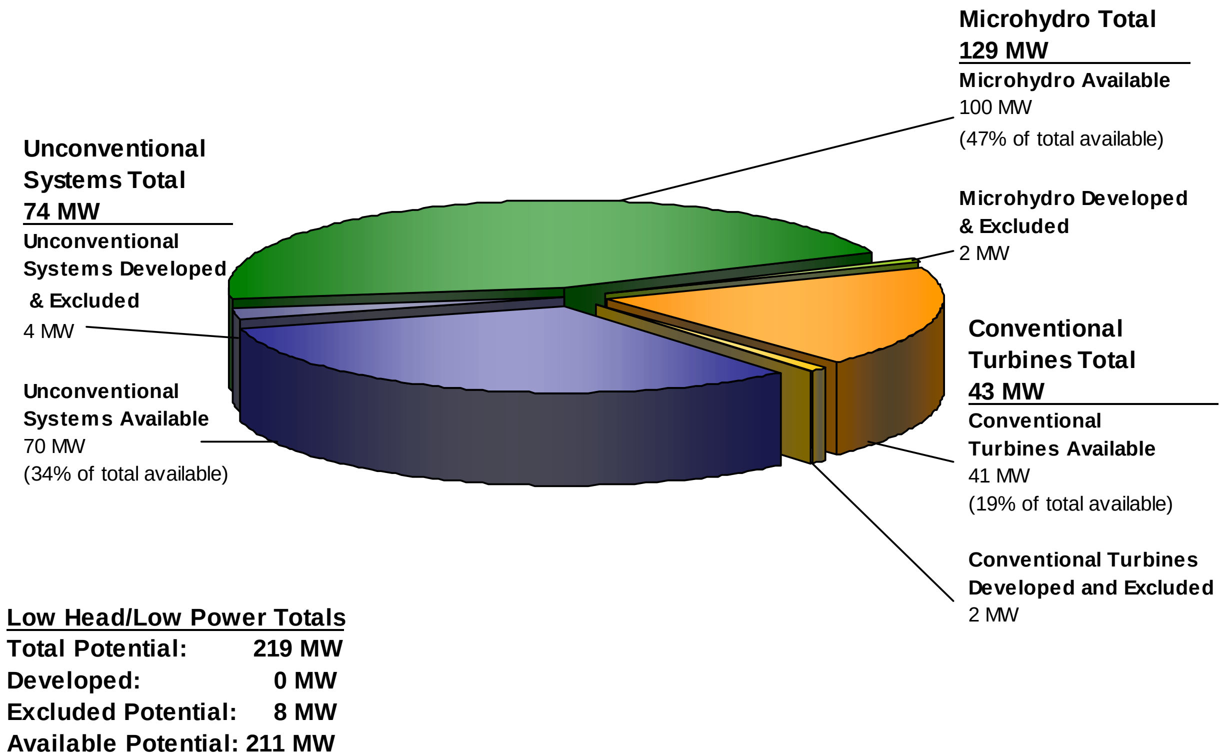


Figure B-39. Distribution of low head/low power hydropower potential in Florida among three low head/low power hydropower technology classes.

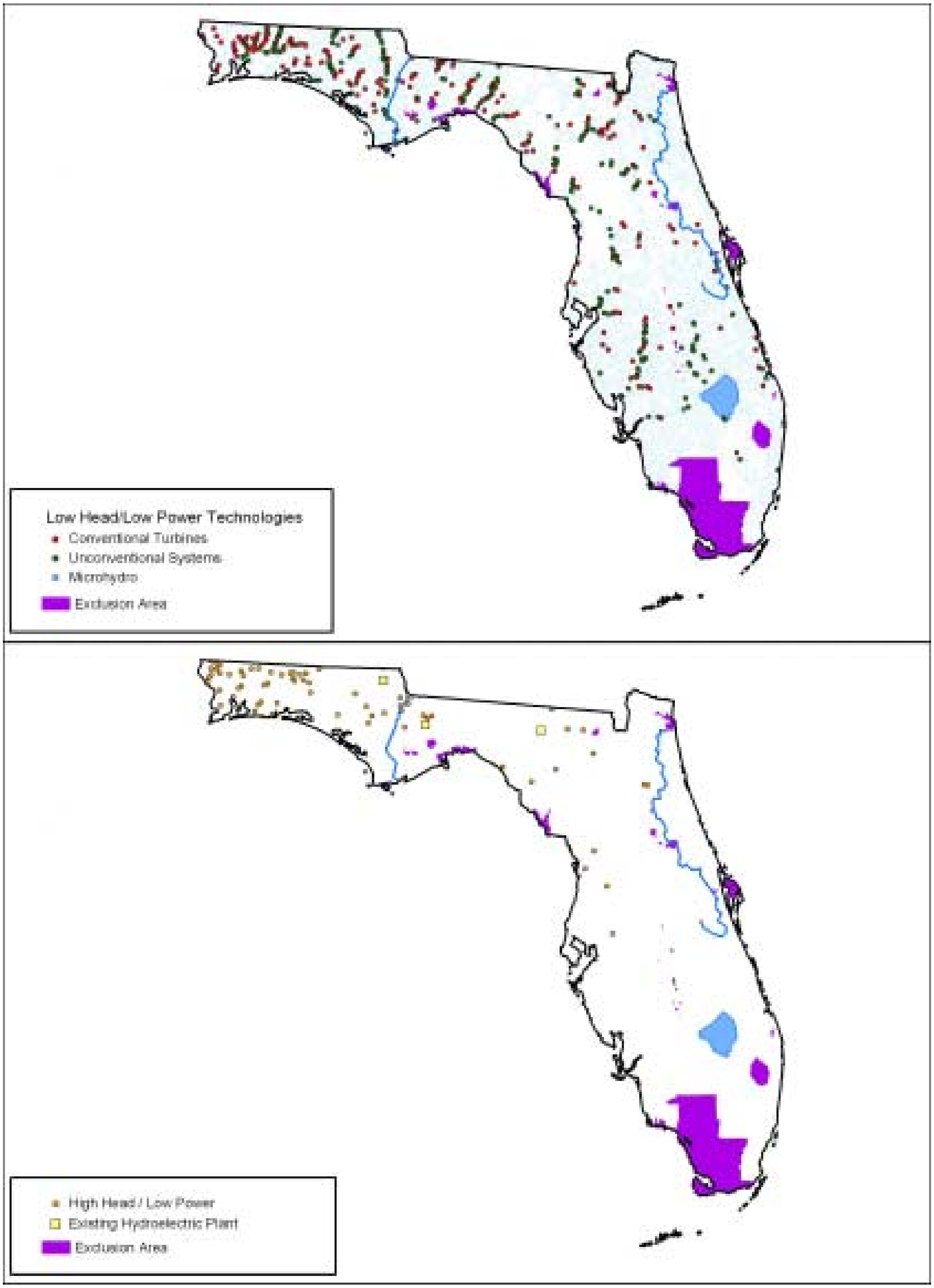


Figure B-40. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Florida.

B.9 Georgia

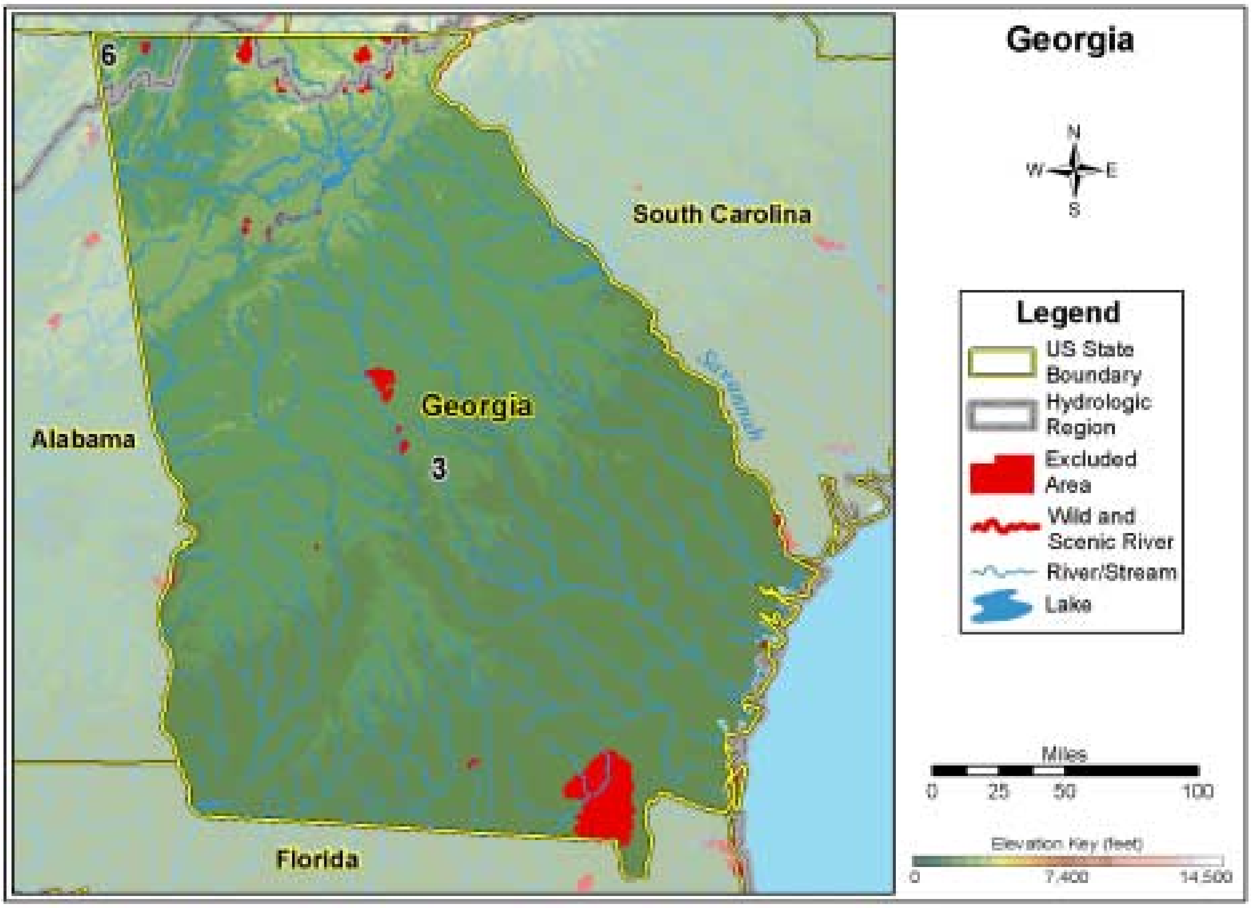


Figure B-41. Georgia.

Table B-9. Summary of results of hydropower resource assessment of Georgia.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**2,249**	**429**	**208**	**1,612**
TOTAL HIGH POWER	**1,436**	**426**	**181**	**829**
High Head/High Power	**804**	**405**	**161**	**238**
Low Head/High Power	**632**	**21**	**20**	**591**
TOTAL LOW POWER	**813**	**3**	**27**	**783**
High Head/Low Power	**250**	**1**	**18**	**231**
Low Head/Low Power	**563**	**2**	**9**	**552**
Conventional Turbine	191	2	3	186
Unconventional Systems	126	0	3	123
Microhydro	246	0	3	243

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

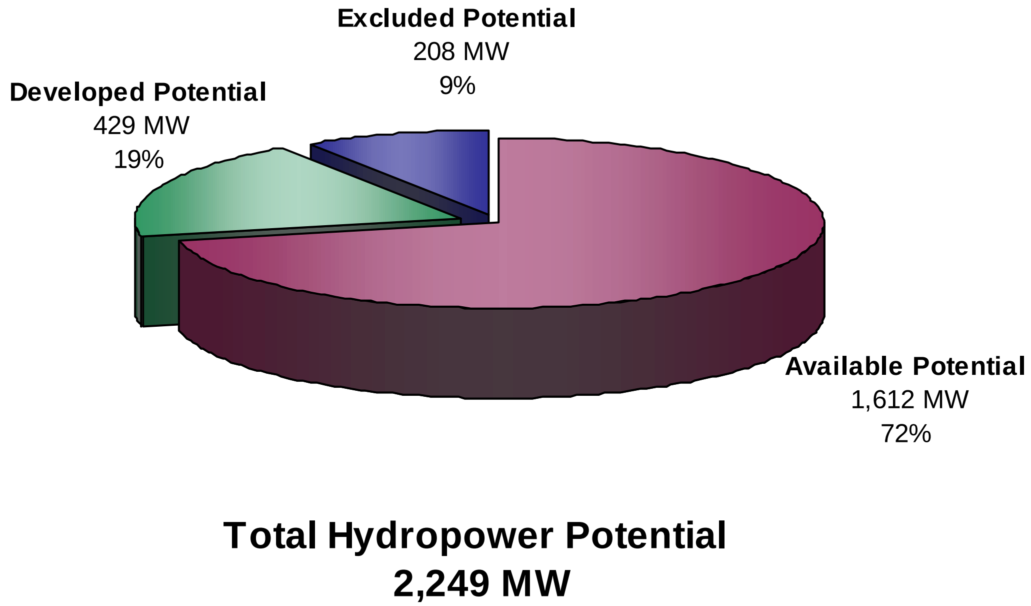


Figure B-42. Distribution of total hydropower potential in Georgia.

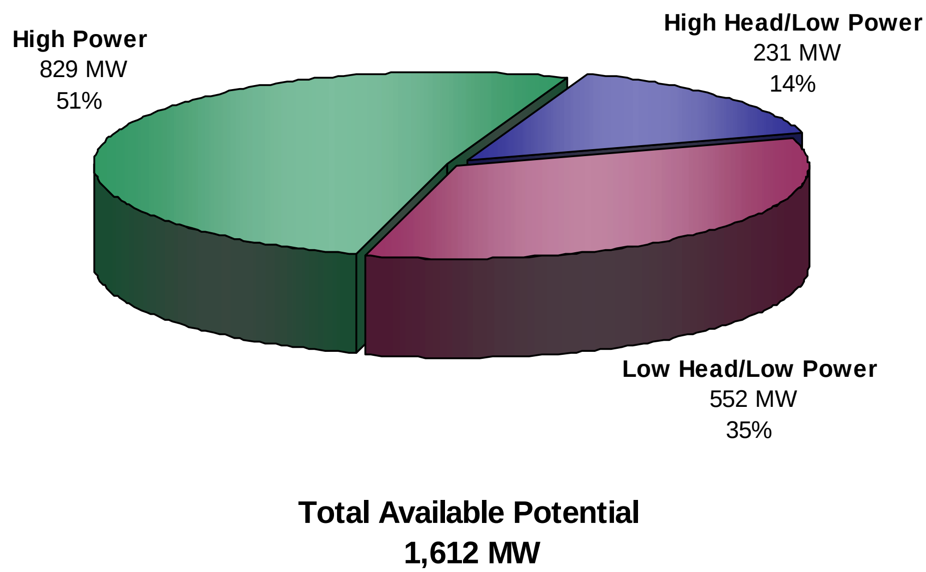


Figure B-43. Distribution of available hydropower potential in Georgia.

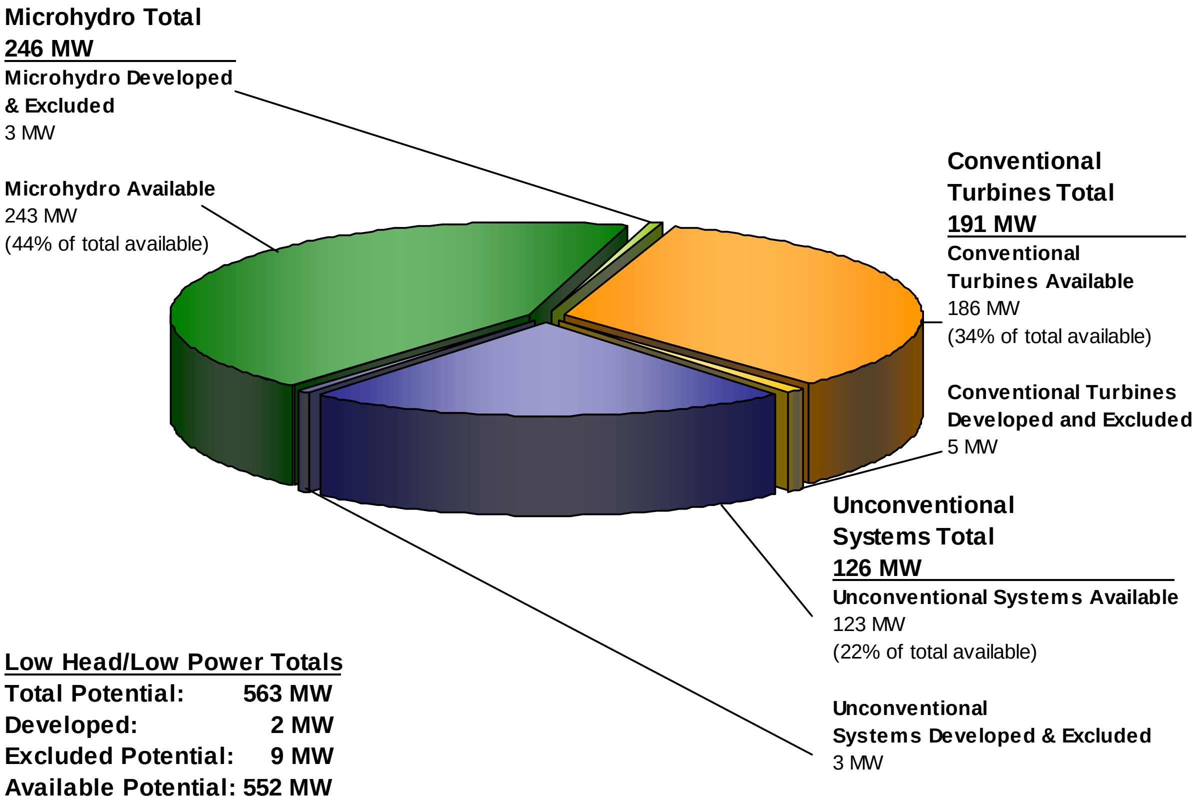


Figure B-44. Distribution of low head/low power hydropower potential in Georgia among three low head/low power hydropower technology classes.

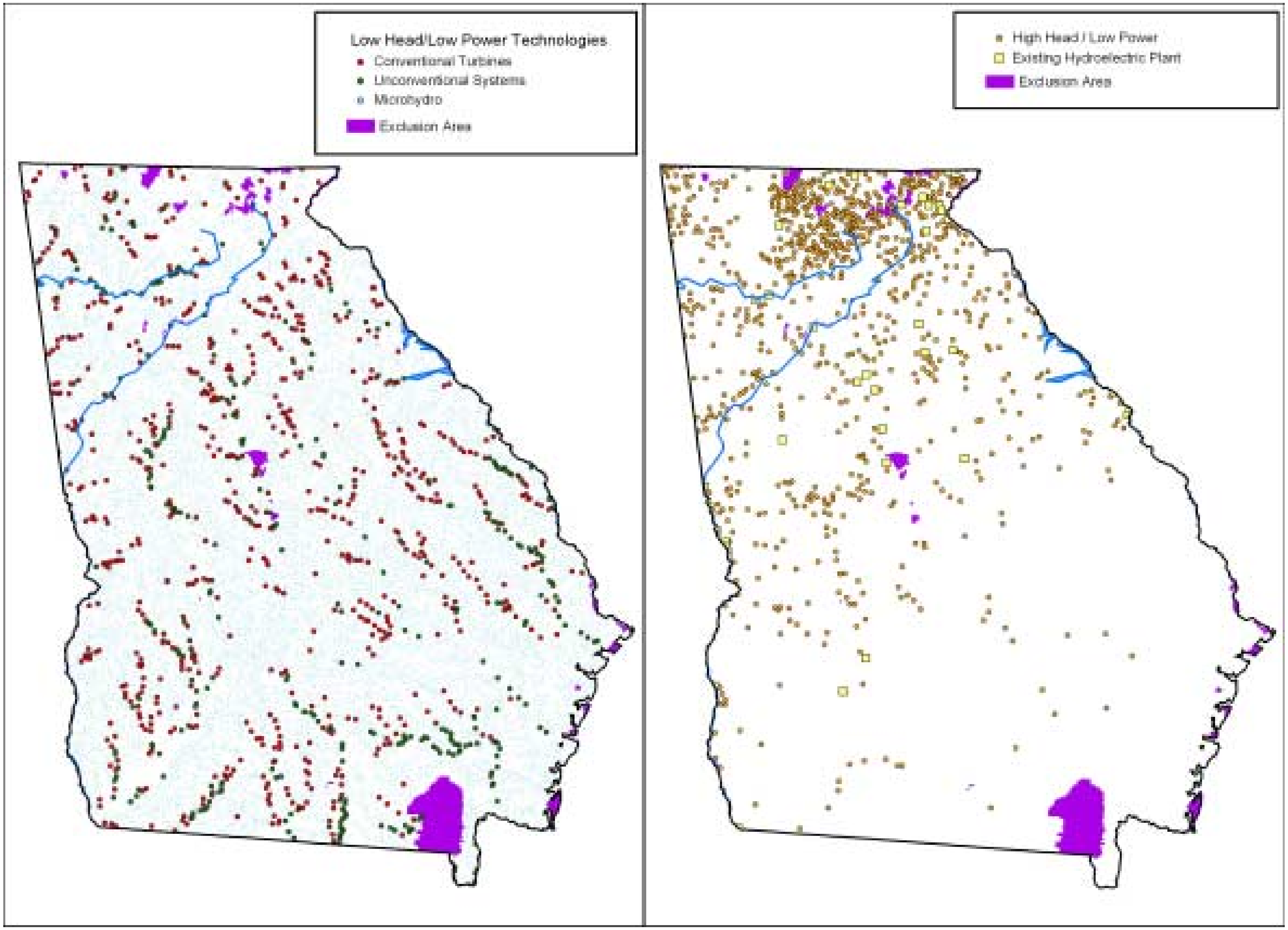


Figure B-45. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Georgia.

B.10 Idaho

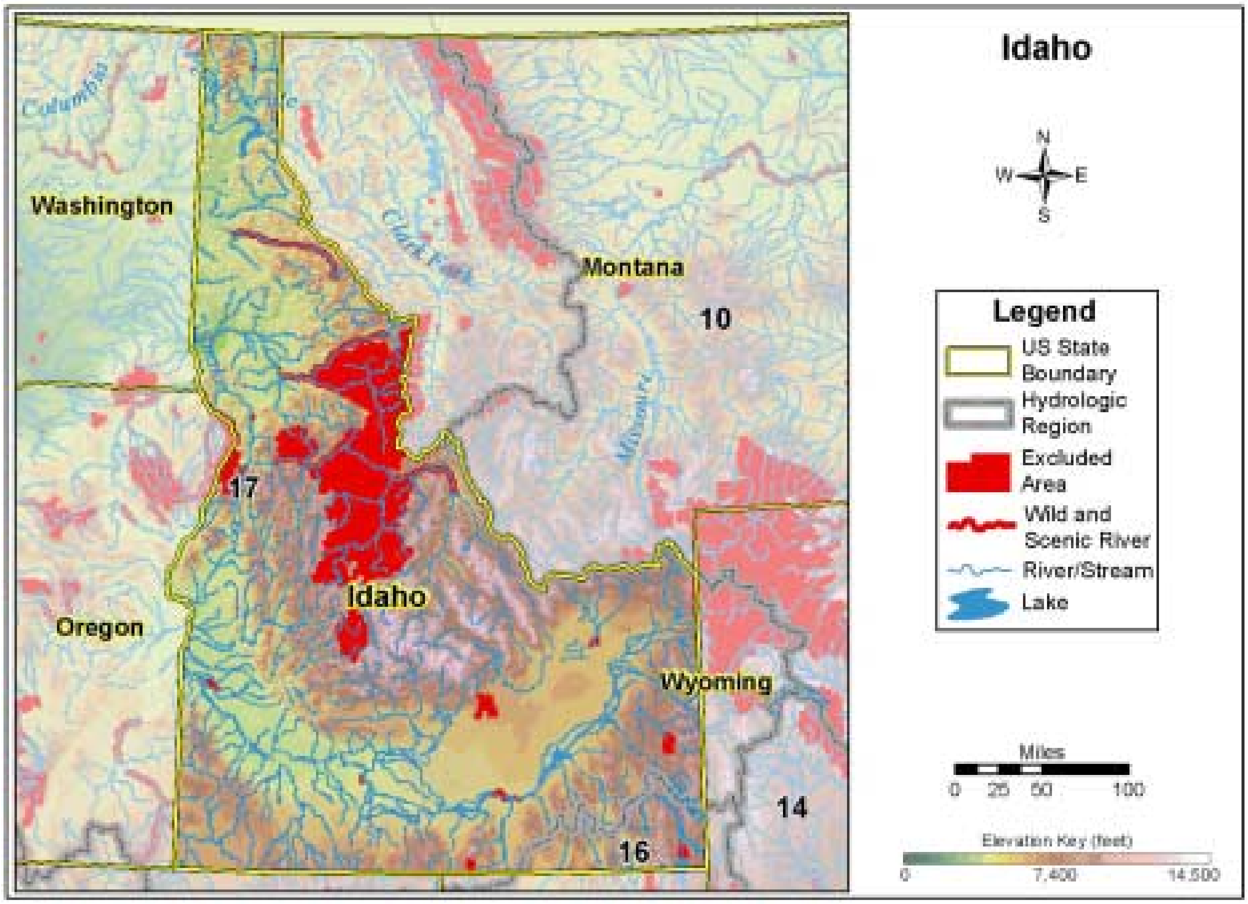


Figure B-46. Idaho.

Table B-10. Summary of results of hydropower resource assessment of Idaho.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**18,794**	**1,293**	**5,545**	**11,956**
TOTAL HIGH POWER	**15,677**	**1,281**	**5,025**	**9,371**
High Head/High Power	**12,207**	**1,208**	**3,890**	**7,109**
Low Head/High Power	**3,470**	**73**	**1,135**	**2,262**
TOTAL LOW POWER	**3,117**	**12**	**520**	**2,585**
High Head/Low Power	**2,532**	**10**	**478**	**2,044**
Low Head/Low Power	**585**	**2**	**42**	**541**
Conventional Turbine	190	2	9	179
Unconventional Systems	88	0	17	71
Microhydro	307	0	16	291

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

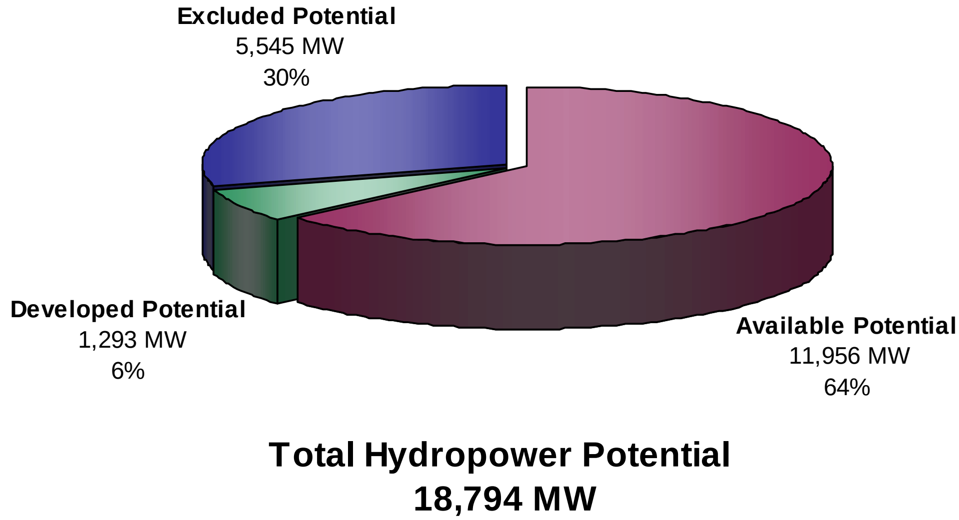


Figure B-47. Distribution of total hydropower potential in Idaho.

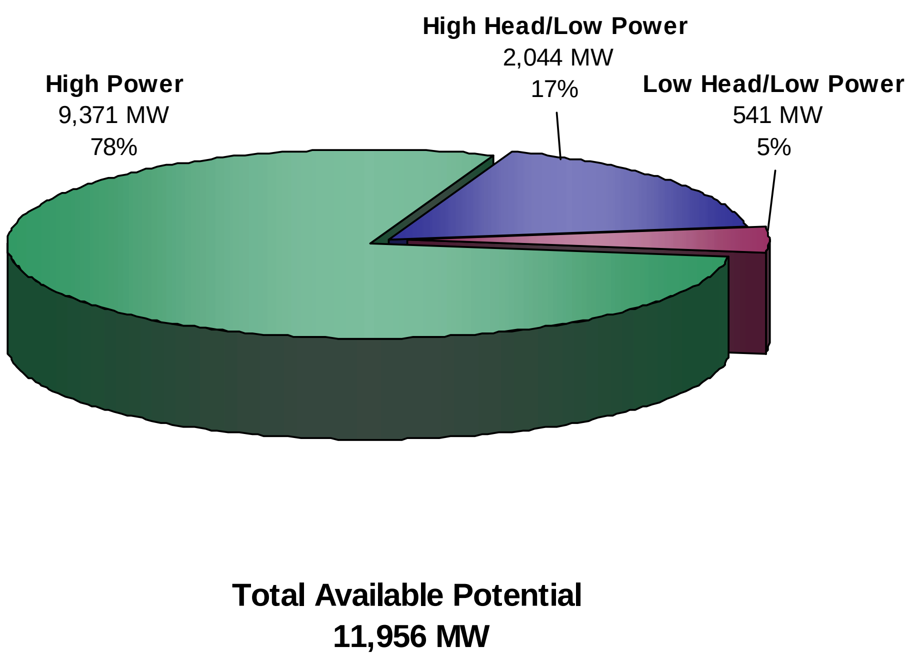


Figure B-48. Distribution of available hydropower potential in Idaho.

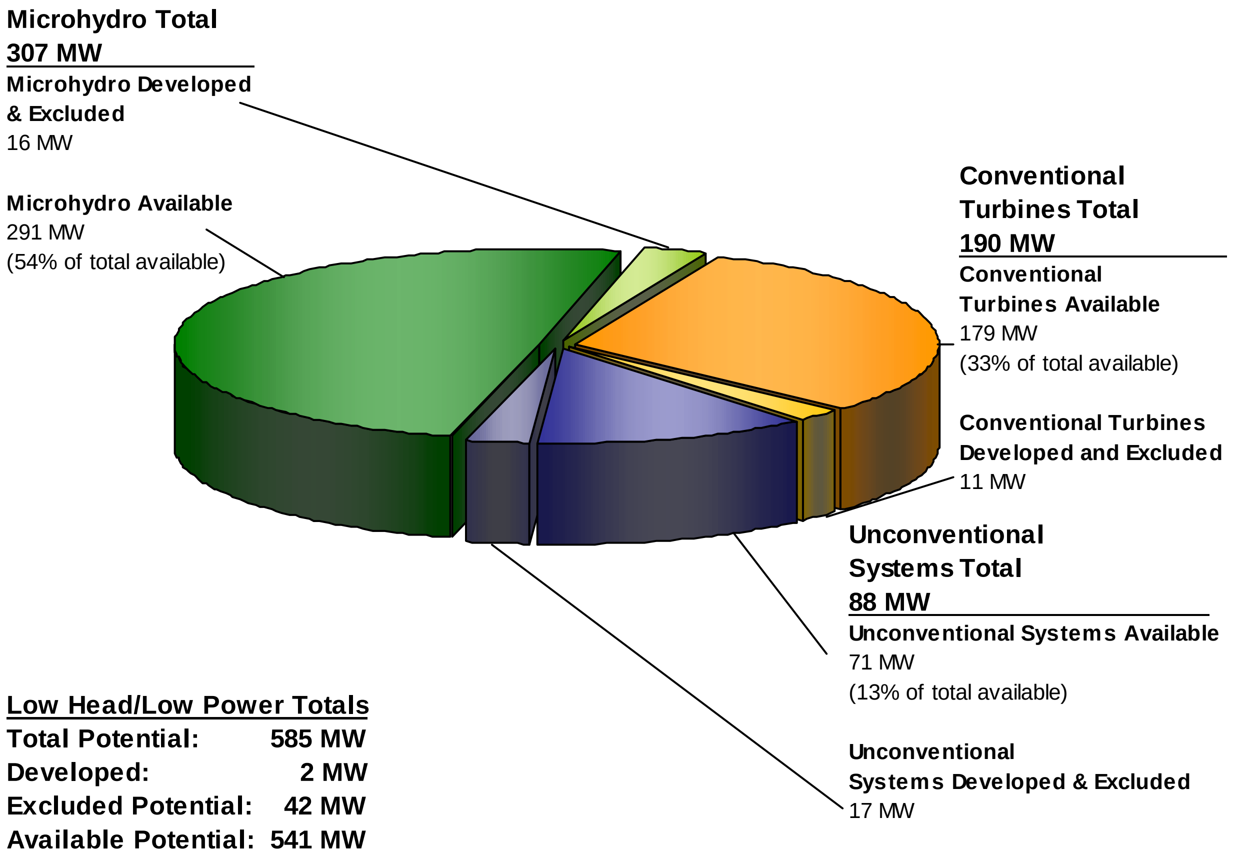


Figure B-49. Distribution of low head/low power hydropower potential in Idaho among three low head/low power hydropower technology classes.

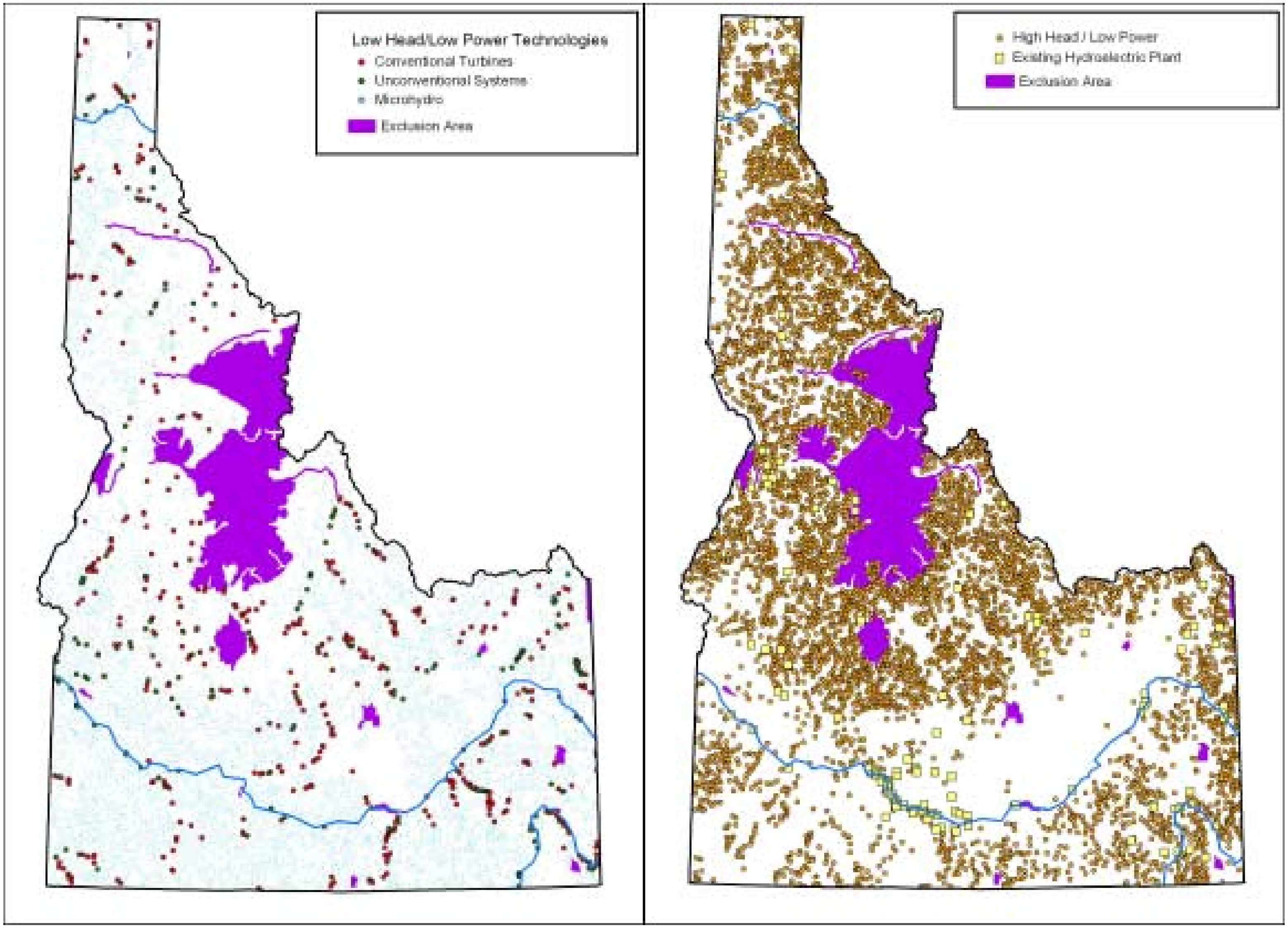


Figure B-50. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Idaho.

B.11 Illinois

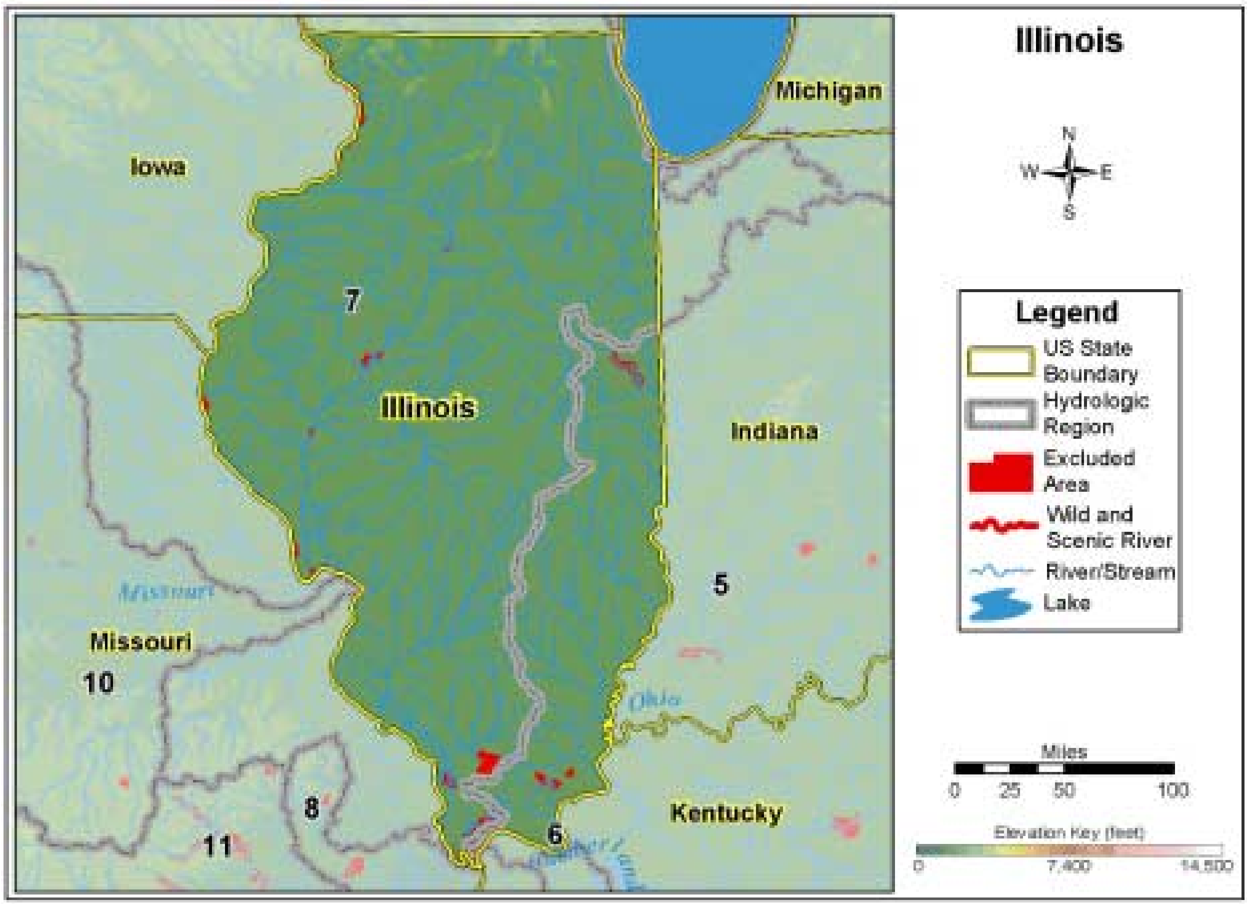


Figure B-51. Illinois.

Table B-11. Summary of results of hydropower resource assessment of Illinois.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,902**	**27**	**297**	**1,578**
TOTAL HIGH POWER	**1,395**	**26**	**224**	**1,145**
High Head/High Power	**12**	**10**	**0**	**2**
Low Head/High Power	**1,383**	**16**	**224**	**1,143**
TOTAL LOW POWER	**507**	**1**	**73**	**433**
High Head/Low Power	**41**	**0**	**2**	**39**
Low Head/Low Power	**466**	**1**	**71**	**394**
Conventional Turbine	109	1	4	104
Unconventional Systems	103	0	3	100
Microhydro	254	0	64	190

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

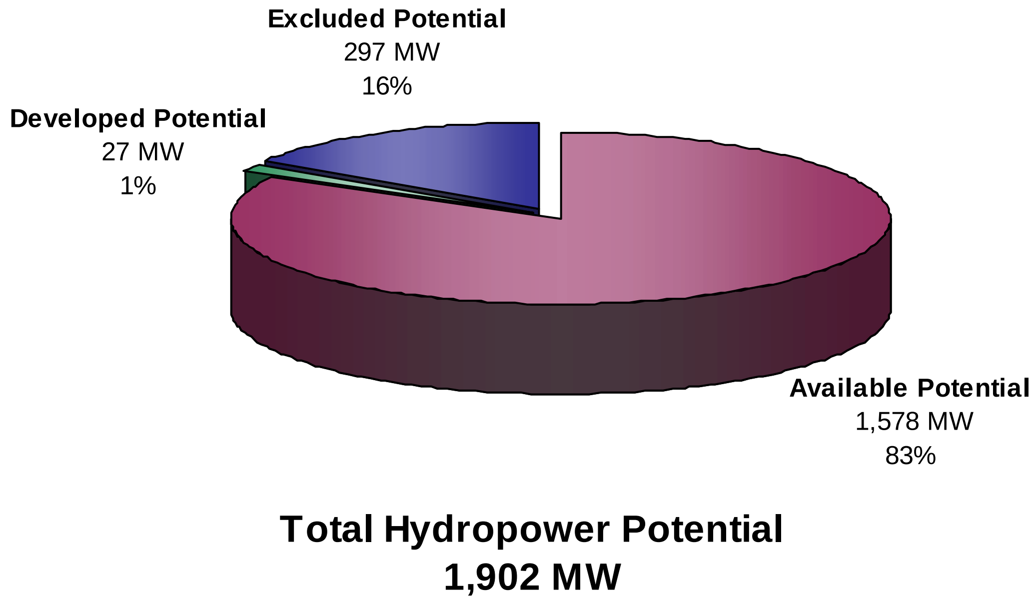


Figure B-52. Distribution of total hydropower potential in Illinois.

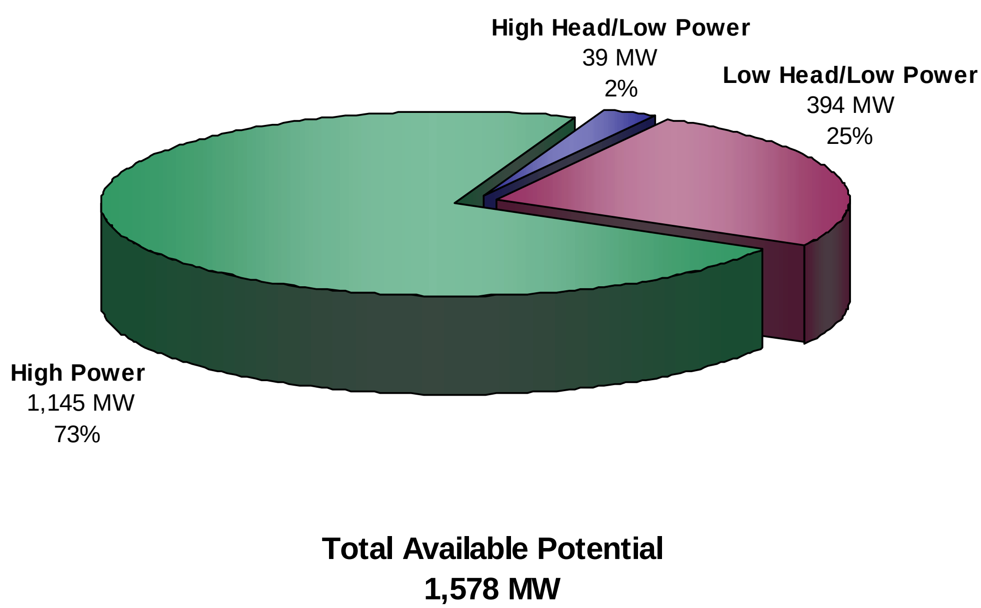


Figure B-53. Distribution of available hydropower potential in Illinois.

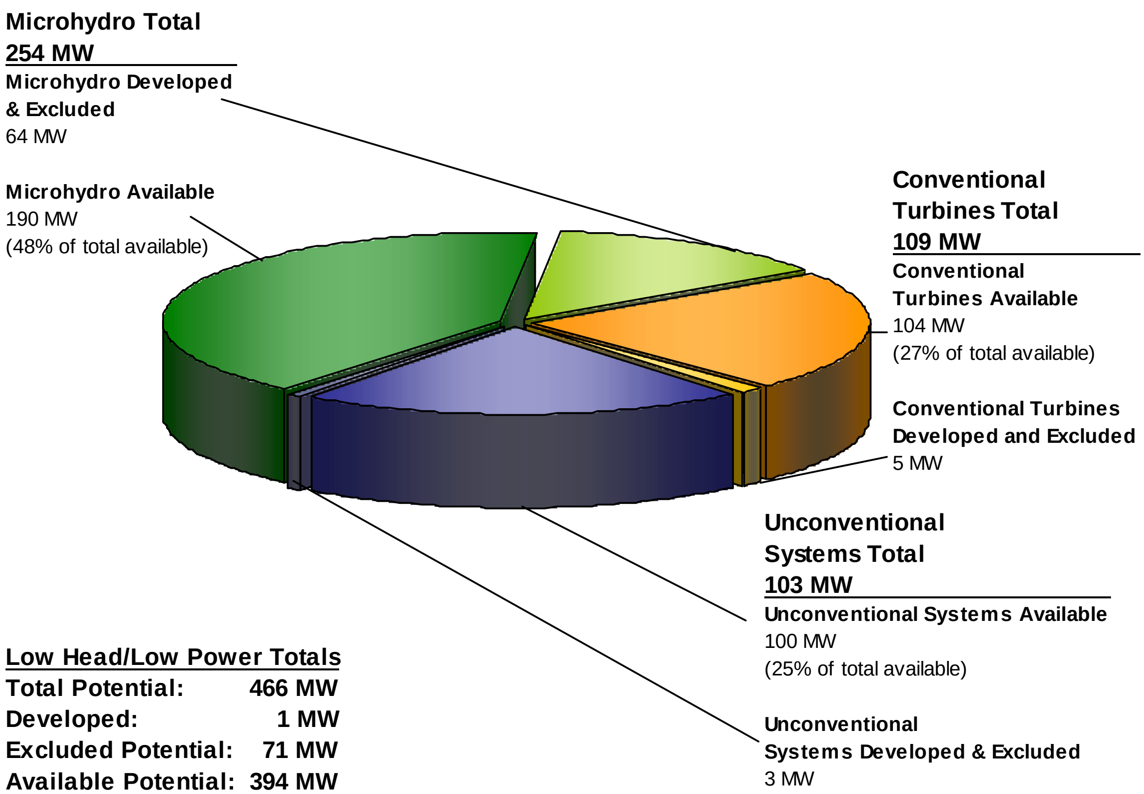


Figure B-54. Distribution of low head/low power hydropower potential in Illinois among three low head/low power hydropower technology classes.

Illinois

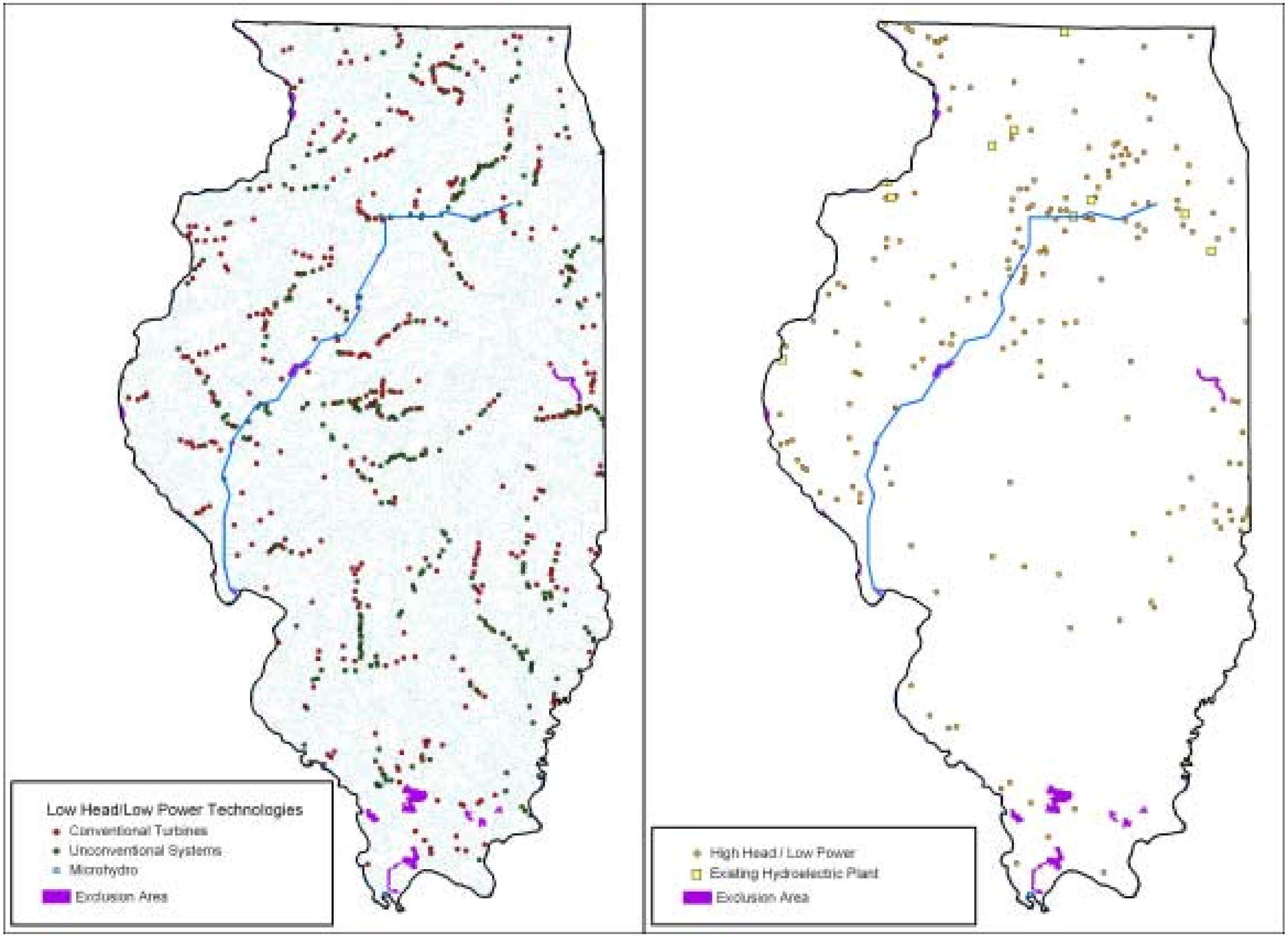


Figure B-55. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Illinois.

B.12 Indiana

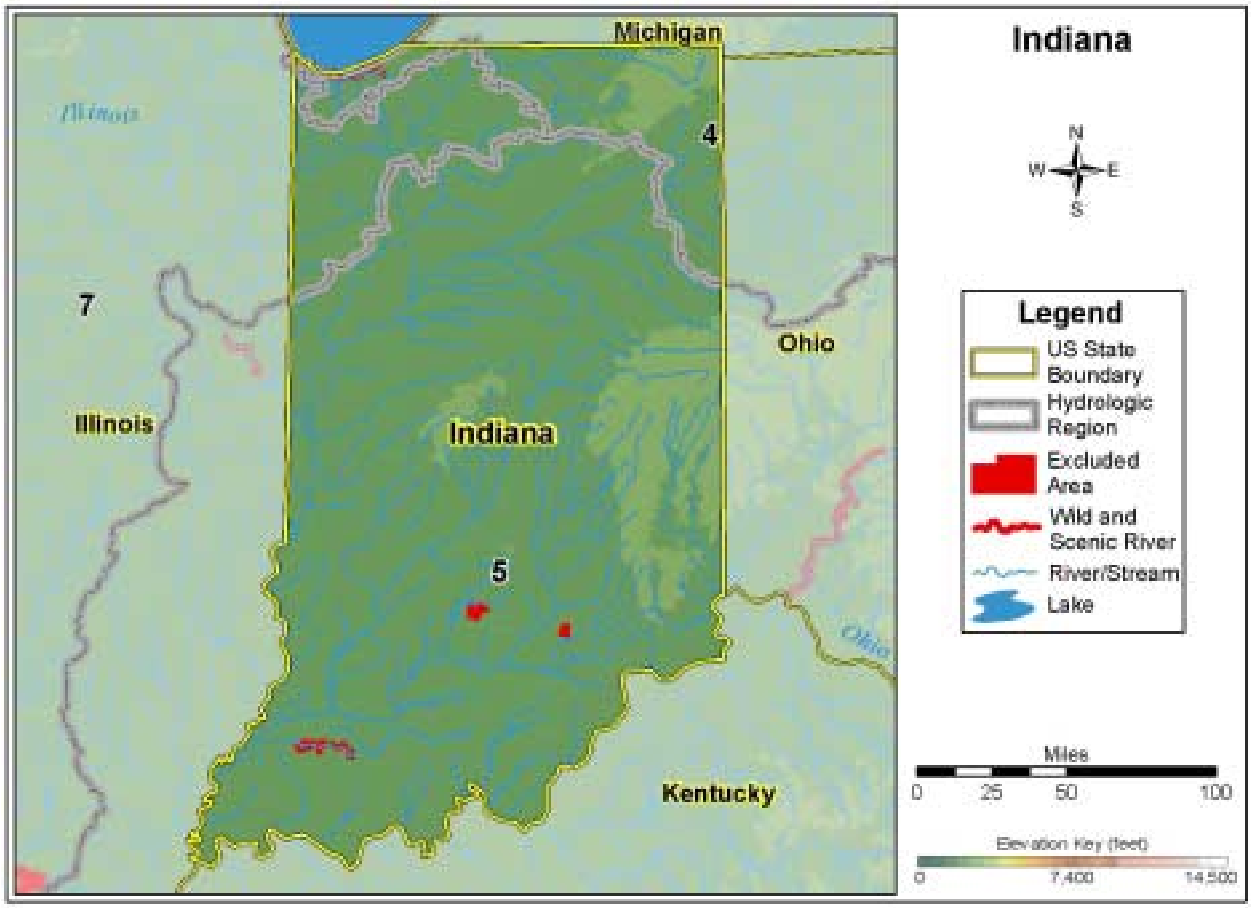


Figure B-56. Indiana.

Table B-12. Summary of results of hydropower resource assessment of Indiana.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,587**	**67**	**4**	**1,516**
TOTAL HIGH POWER	**1,192**	**67**	**1**	**1,124**
High Head/High Power	**353**	**63**	**0**	**290**
Low Head/High Power	**839**	**4**	**1**	**834**
TOTAL LOW POWER	**395**	**0**	**3**	**392**
High Head/Low Power	**82**	**0**	**0**	**82**
Low Head/Low Power	**313**	**0**	**3**	**310**
Conventional Turbine	117	0	1	116
Unconventional Systems	62	0	1	61
Microhydro	134	0	1	133

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

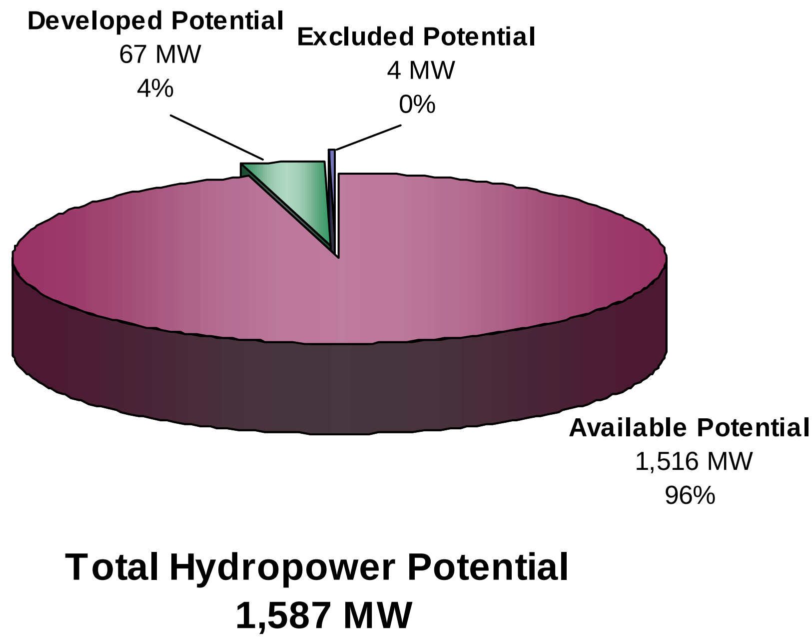


Figure B-57. Distribution of total hydropower potential in Indiana.

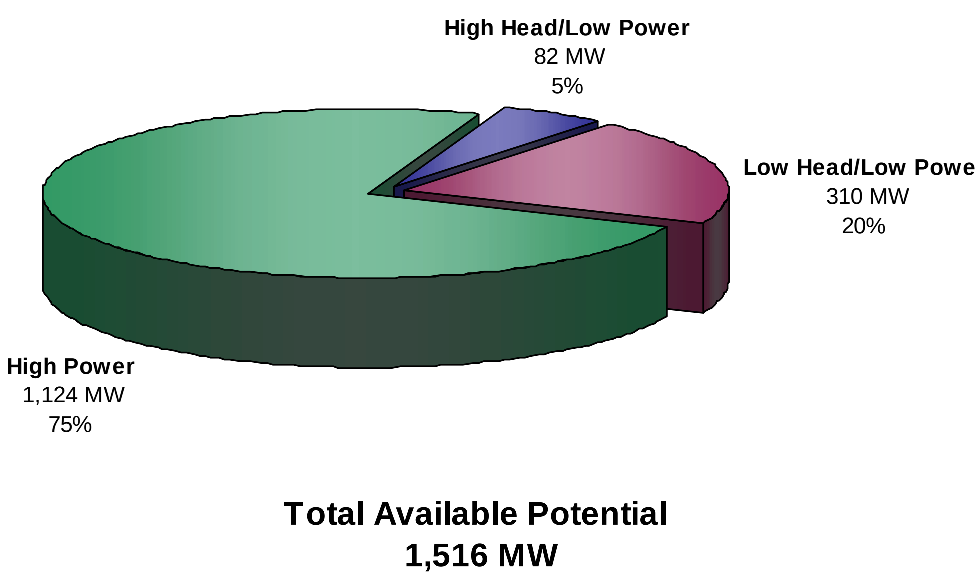


Figure B-58. Distribution of available hydropower potential in Indiana.

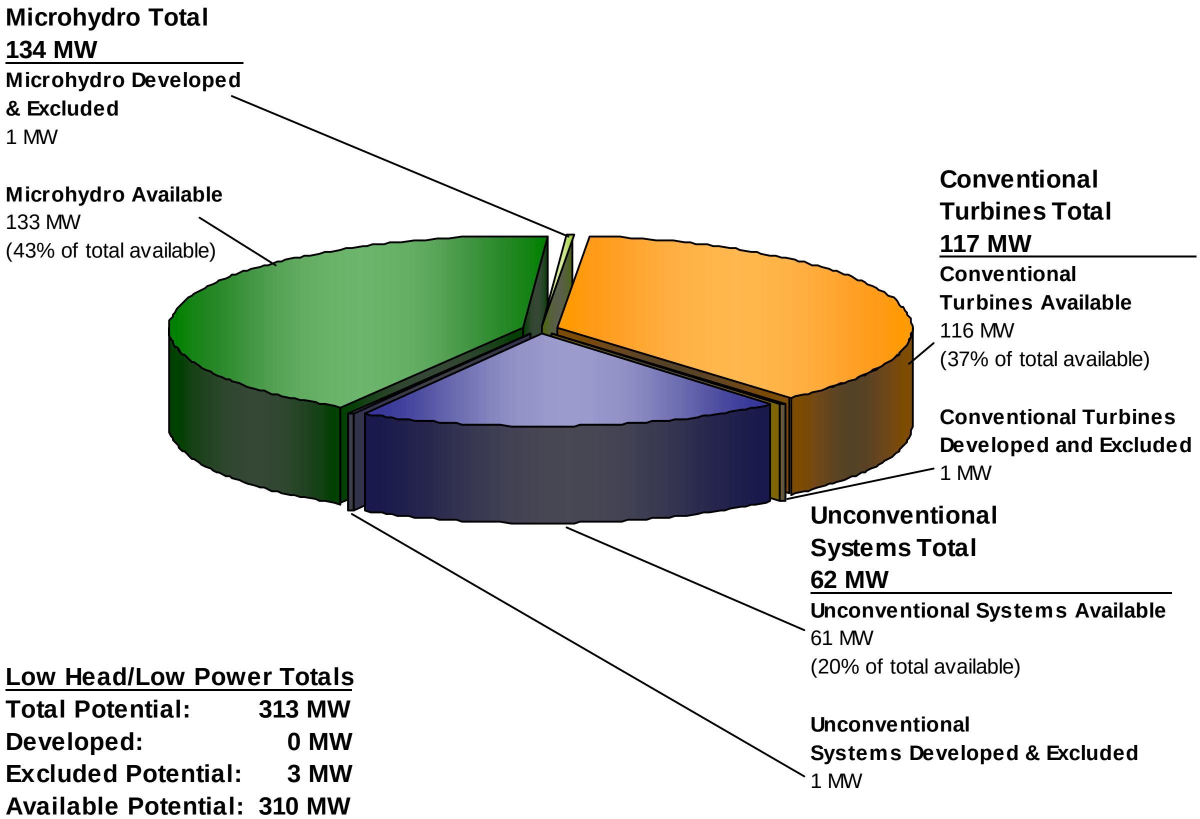


Figure B-59. Distribution of low head/low power hydropower potential in Indiana among three low head/low power hydropower technology classes.

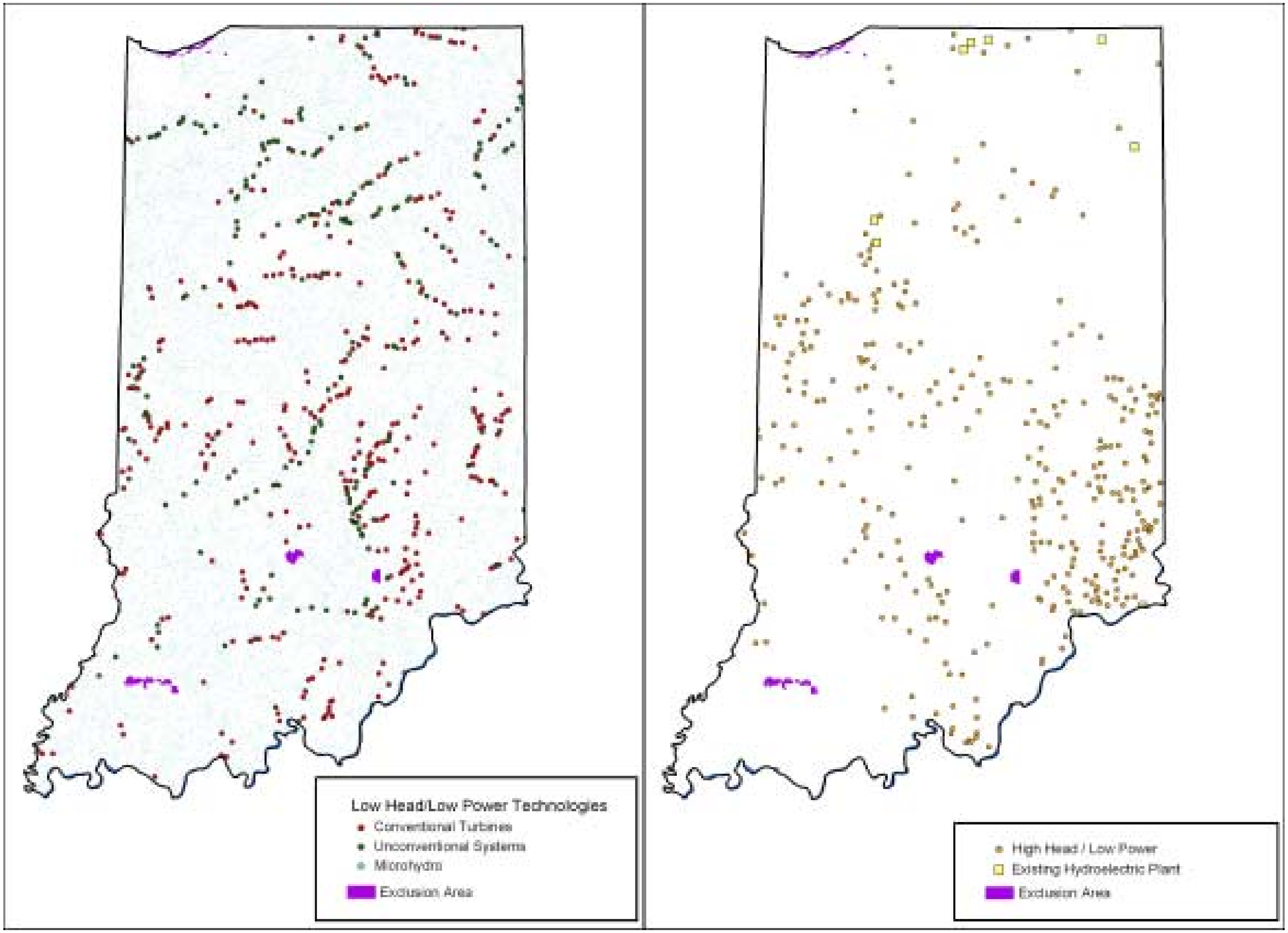


Figure B-60. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Indiana.

B.13 Iowa

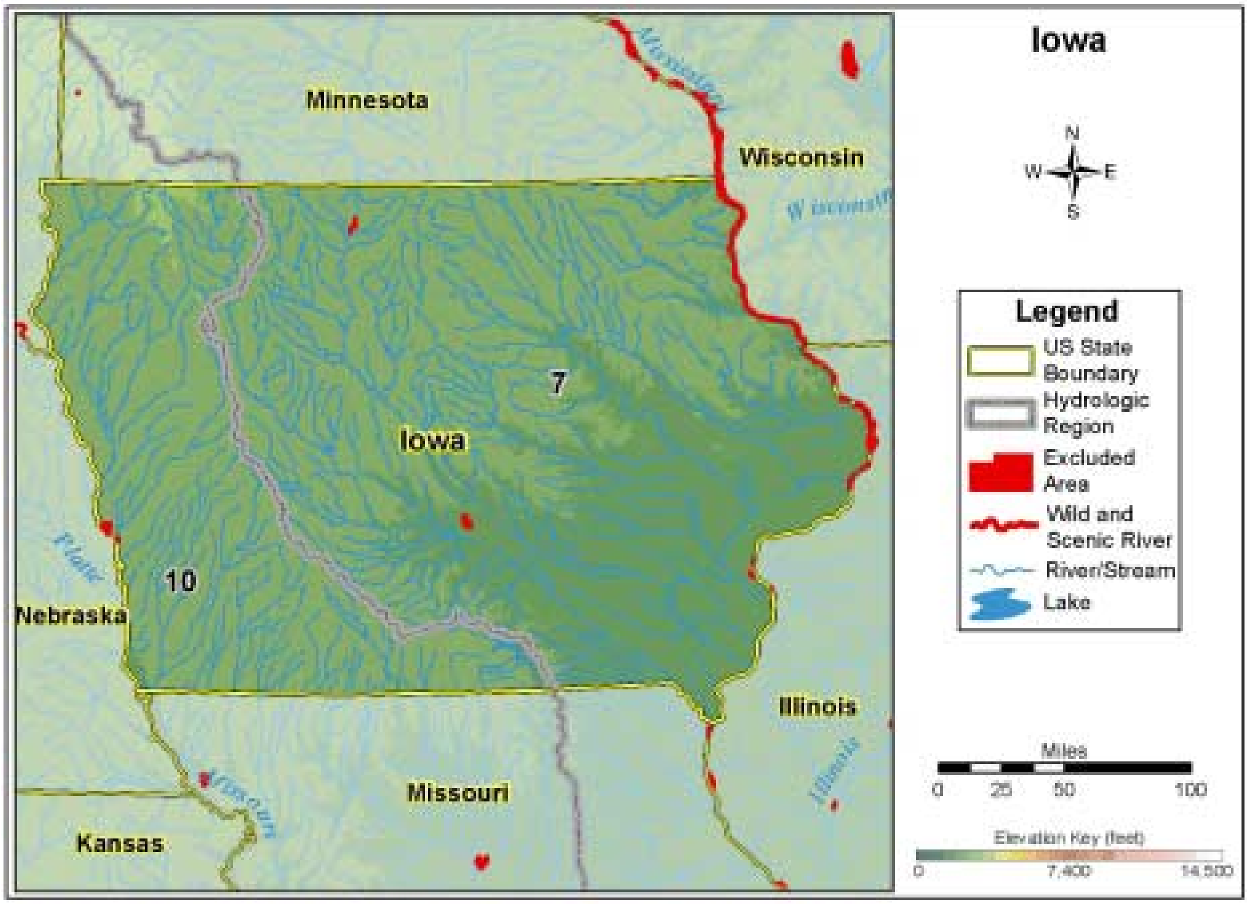


Figure B-61. Iowa.

Table B-13. Summary of results of hydropower resource assessment of Iowa.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,124**	**95**	**127**	**954**
TOTAL HIGH POWER	**578**	**95**	**123**	**412**
High Head/High Power	**40**	**92**	**0**	**—**
Low Head/High Power	**538**	**3**	**123**	**412**
TOTAL LOW POWER	**546**	**0**	**4**	**542**
High Head/Low Power	**49**	**0**	**0**	**49**
Low Head/Low Power	**497**	**0**	**4**	**493**
Conventional Turbine	185	0	1	184
Unconventional Systems	110	0	2	108
Microhydro	202	0	1	201

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

Note: Available high head/high power potential was negative possibly due to overestimation of developed potential. The available high head/high power value is considered unreasonable and is not included in the power class rollup. The total power and total high power available values are rolled up values that do not match the value obtained by horizontal summing of power category values.

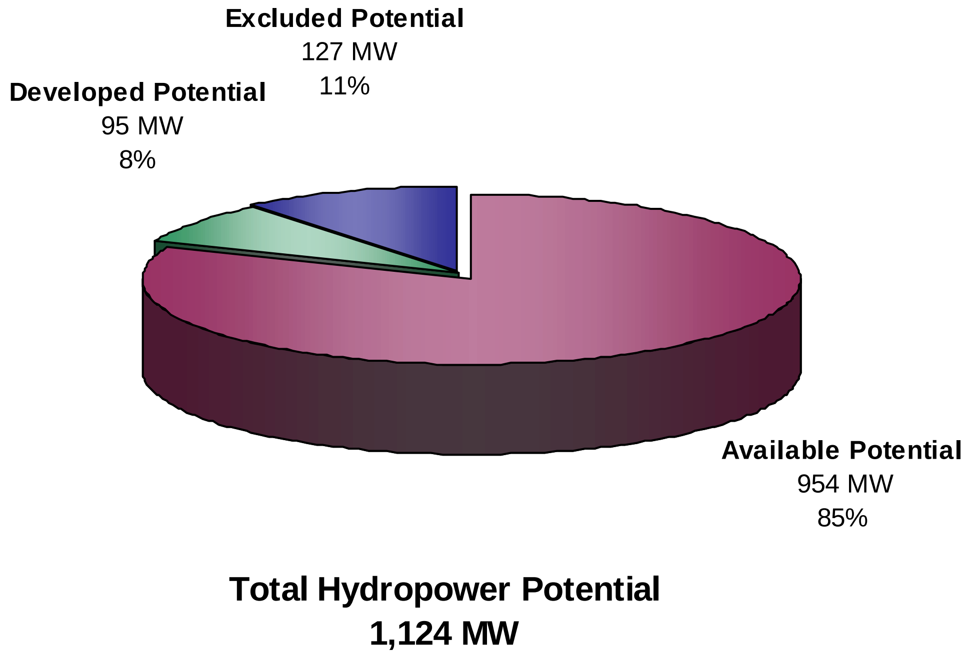


Figure B-62. Distribution of total hydropower potential in Iowa.

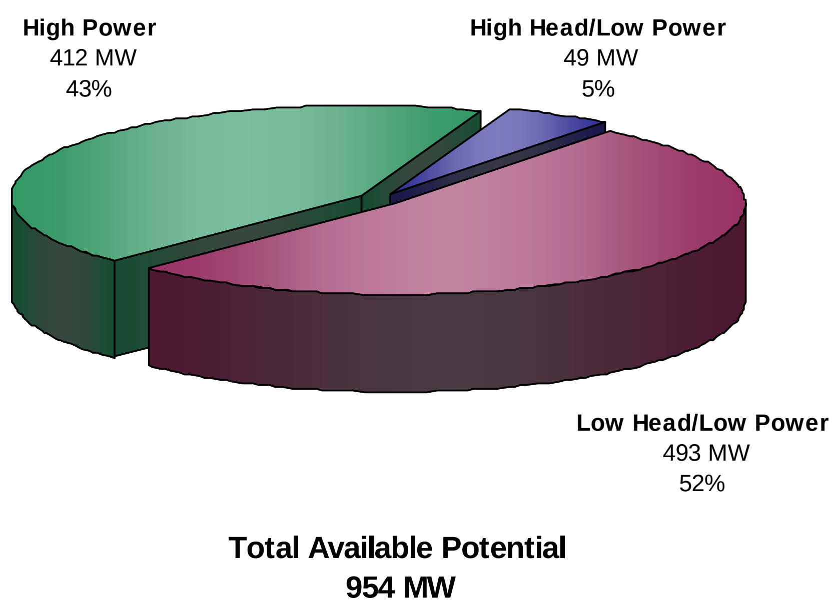


Figure B-63. Distribution of available hydropower potential in Iowa.

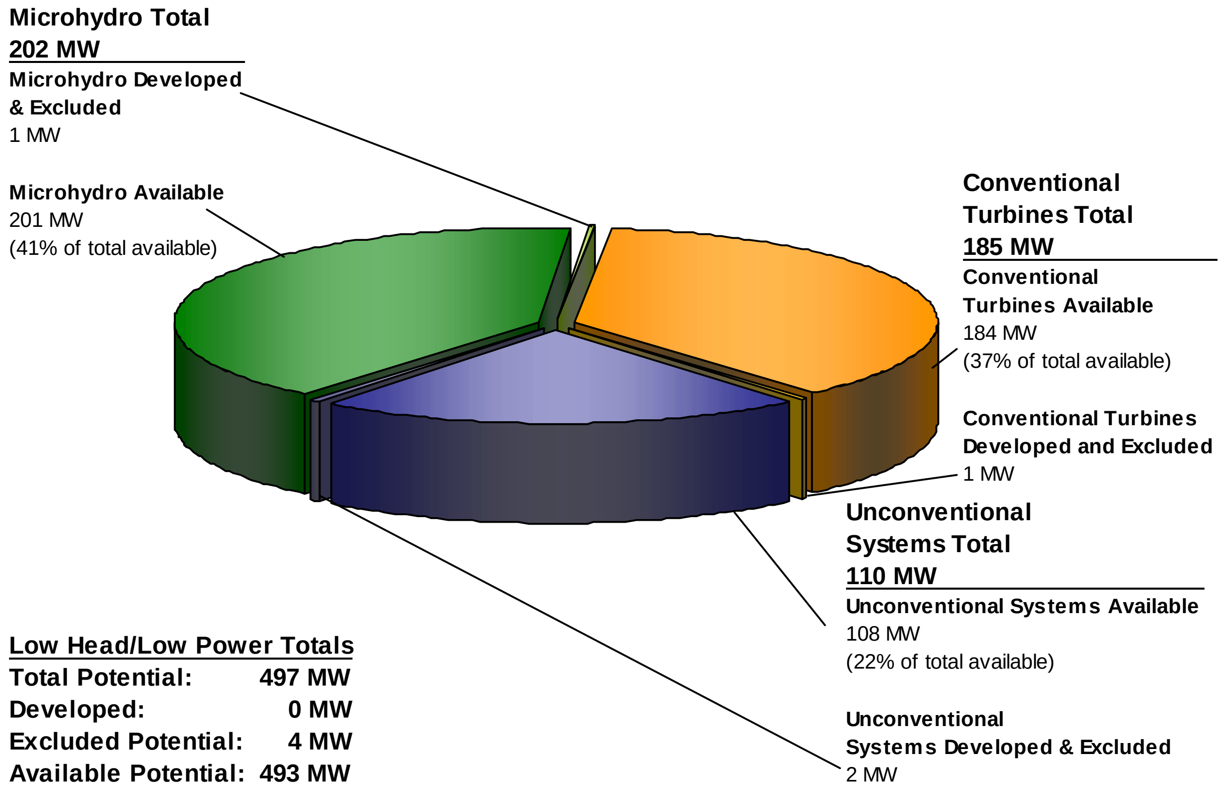


Figure B-64. Distribution of low head/low power hydropower potential in Iowa among three low head/low power hydropower technology classes.

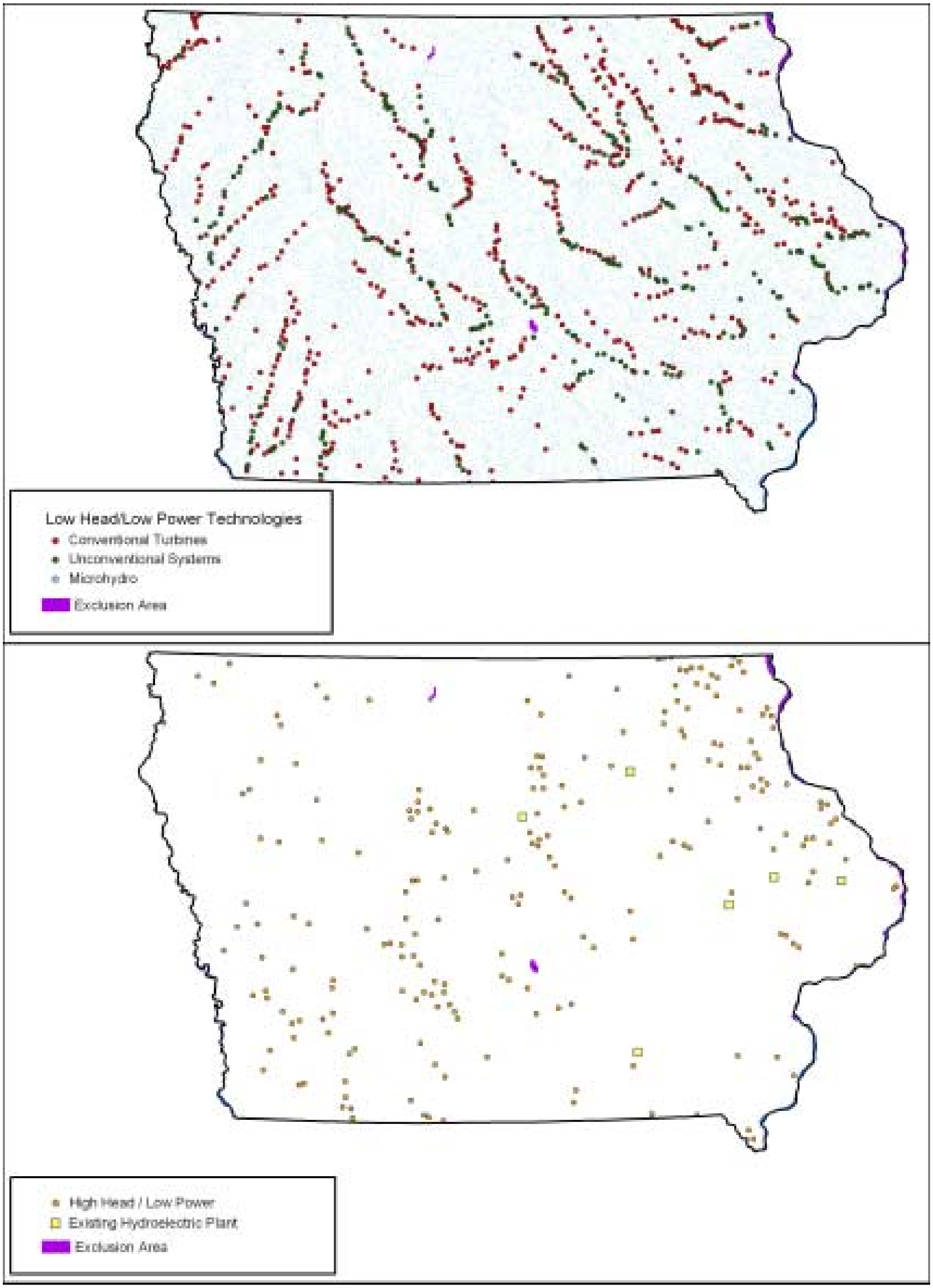


Figure B-65. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Iowa.

B.14 Kansas

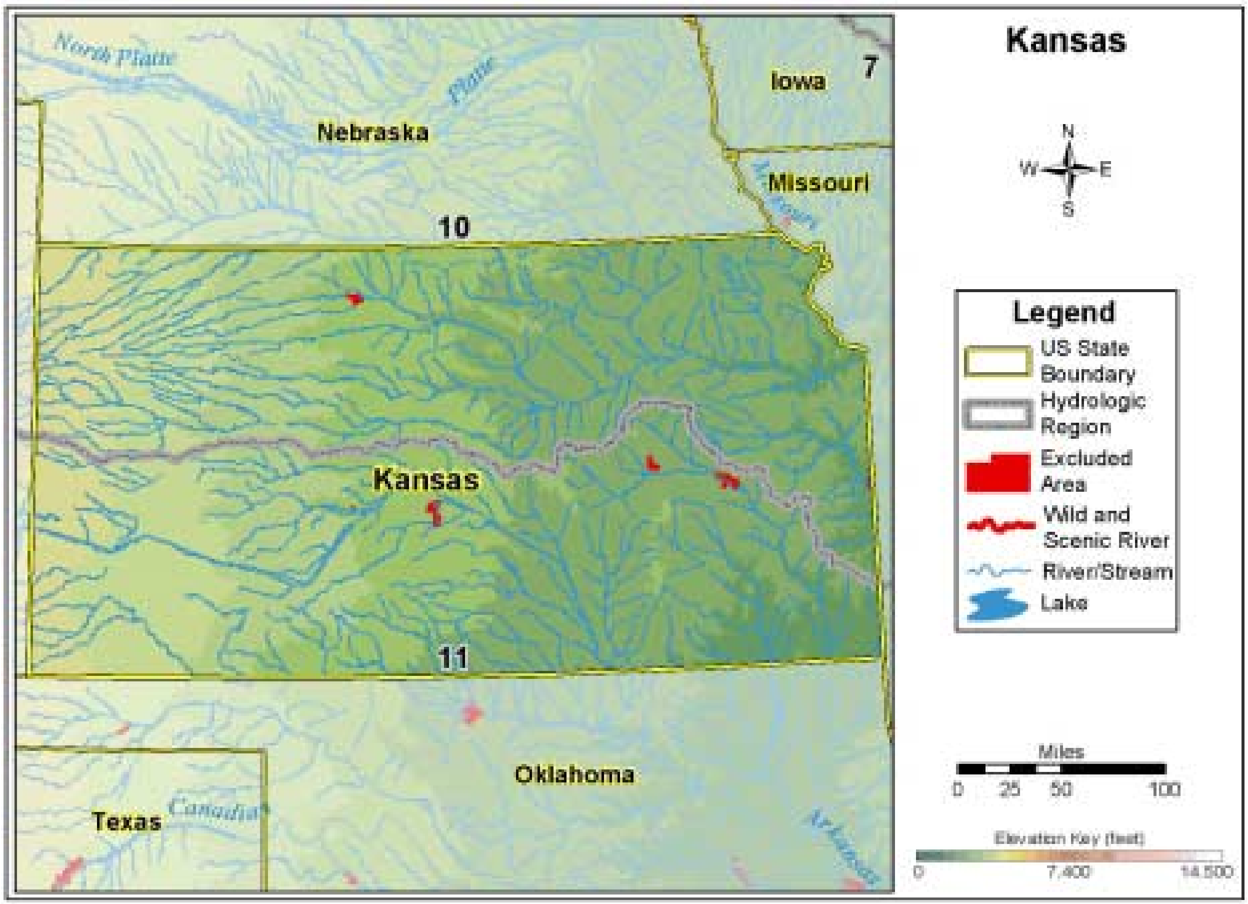


Figure B-66. Kansas.

Table B-14. Summary of results of hydropower resource assessment of Kansas.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**989**	**1**	**3**	**985**
TOTAL HIGH POWER	**418**	**1**	**0**	**417**
High Head/High Power	**49**	**0**	**0**	**49**
Low Head/High Power	**369**	**1**	**0**	**368**
TOTAL LOW POWER	**571**	**0**	**3**	**568**
High Head/Low Power	**38**	**0**	**0**	**38**
Low Head/Low Power	**533**	**0**	**3**	**530**
Conventional Turbine	192	0	1	191
Unconventional Systems	81	0	1	80
Microhydro	260	0	1	259

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

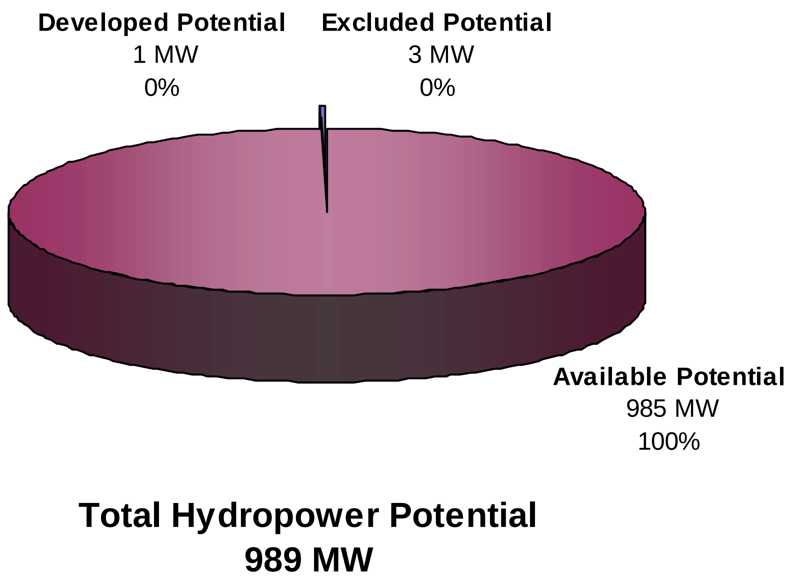


Figure B-67. Distribution of total hydropower potential in Kansas.

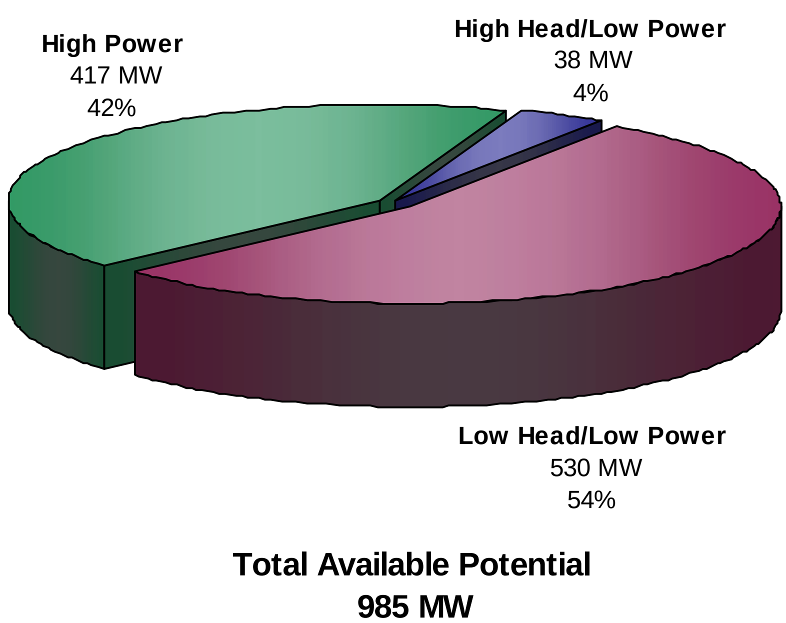


Figure B-68. Distribution of available hydropower potential in Kansas.

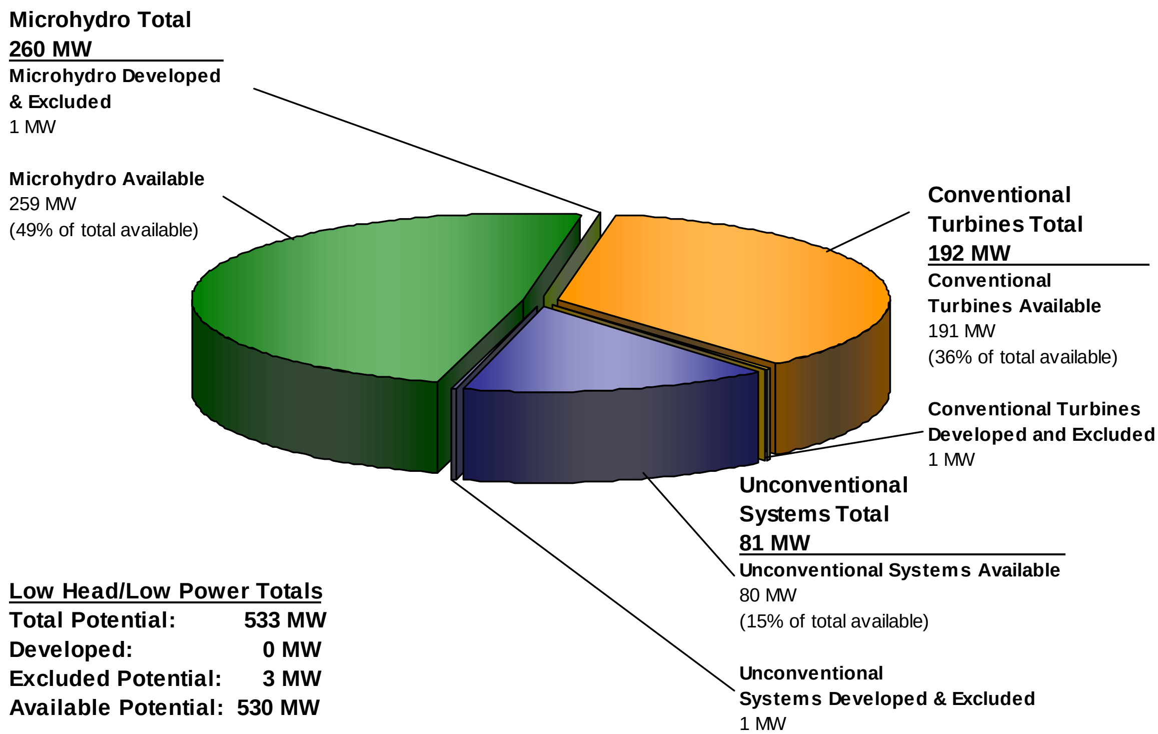


Figure B-69. Distribution of low head/low power hydropower potential in Kansas among three low head/low power hydropower technology classes.

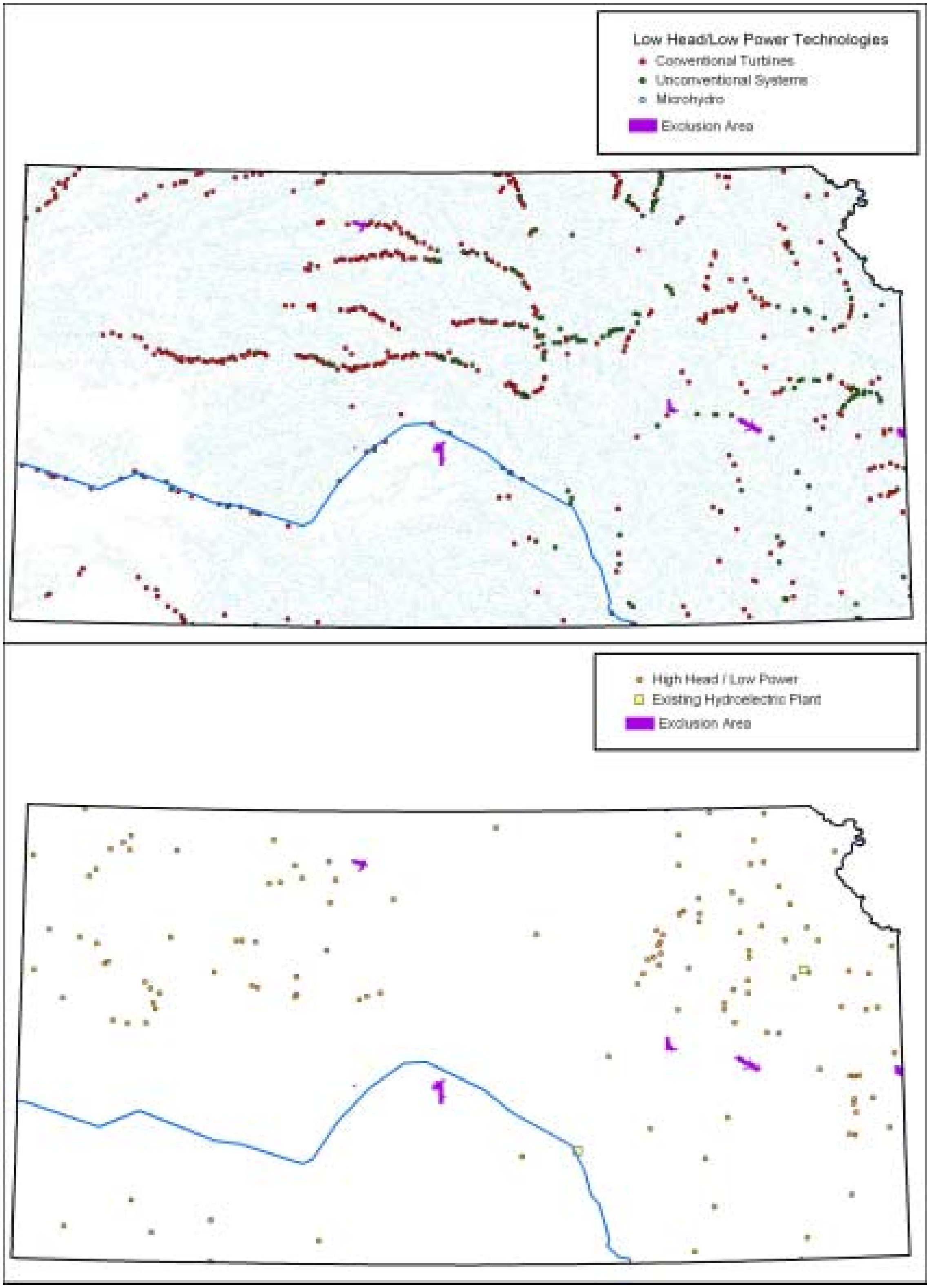


Figure B-70. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Kansas.

B.15 Kentucky

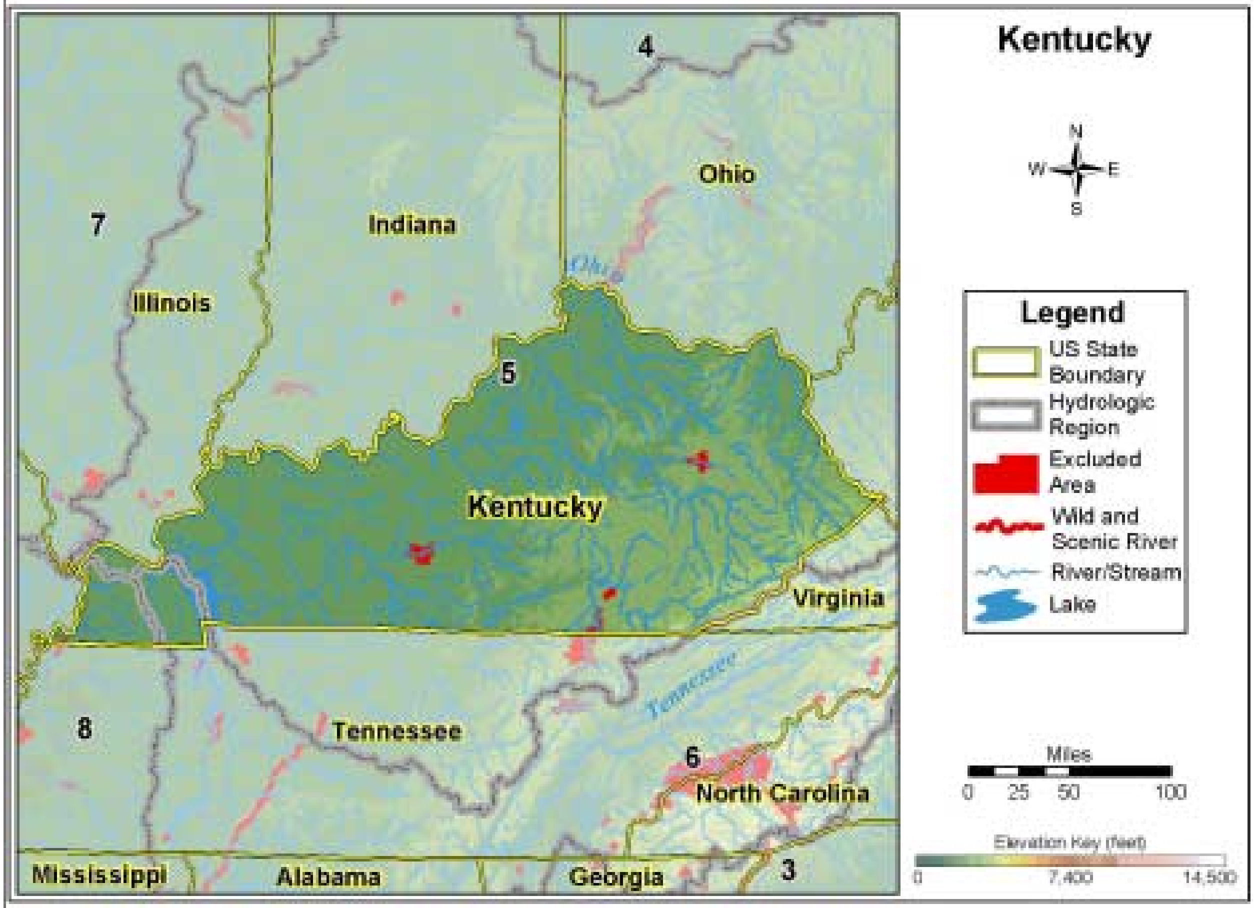


Figure B-71. Kentucky.

Table B-16. Summary of results of hydropower resource assessment of Kentucky.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**4,116**	**383**	**46**	**3,687**
TOTAL HIGH POWER	**3,526**	**382**	**33**	**3,111**
High Head/High Power	**780**	**381**	**16**	**383**
Low Head/High Power	**2,746**	**1**	**17**	**2,728**
TOTAL LOW POWER	**590**	**1**	**13**	**576**
High Head/Low Power	**204**	**0**	**7**	**197**
Low Head/Low Power	**386**	**1**	**6**	**379**
Conventional Turbine	138	1	2	135
Unconventional Systems	51	0	2	49
Microhydro	197	0	2	195

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

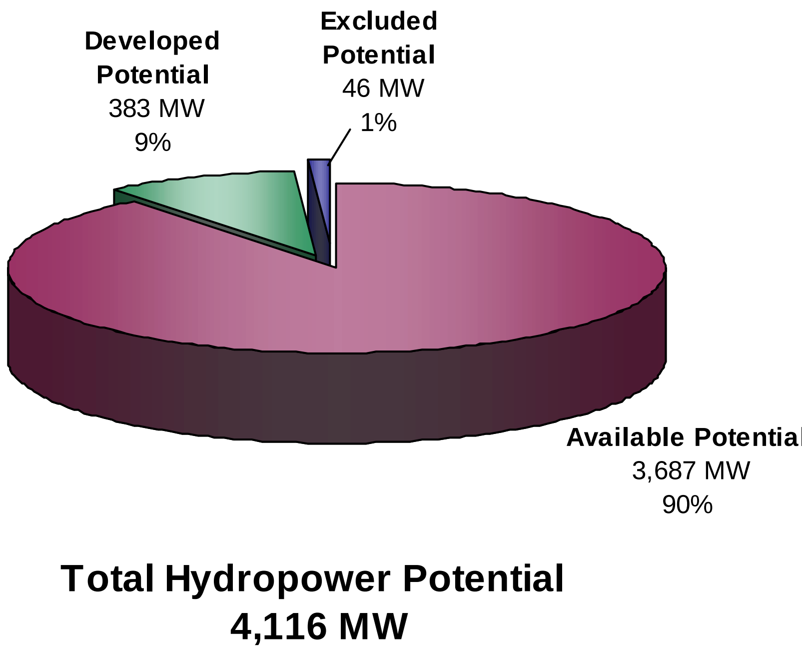


Figure B-72. Distribution of total hydropower potential in Kentucky.

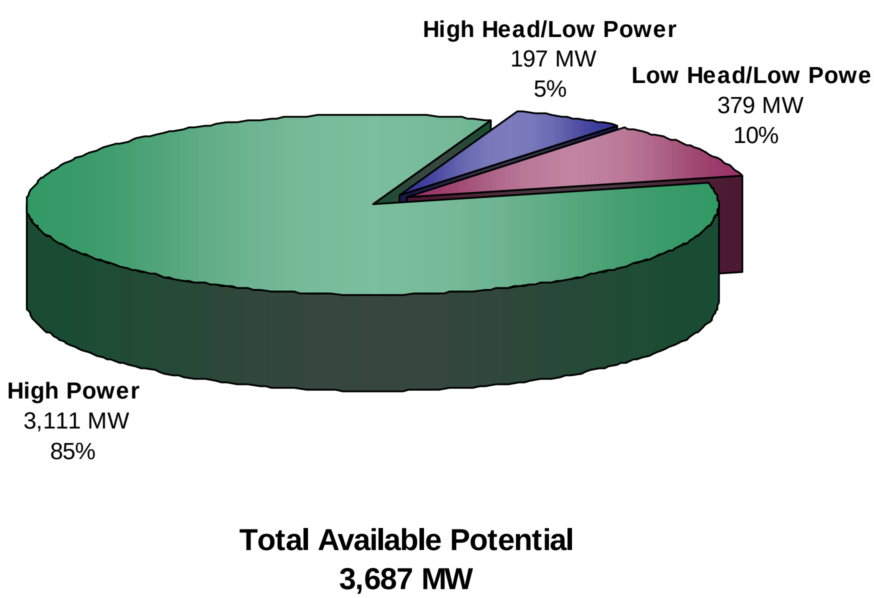


Figure B-73. Distribution of available hydropower potential in Kentucky.

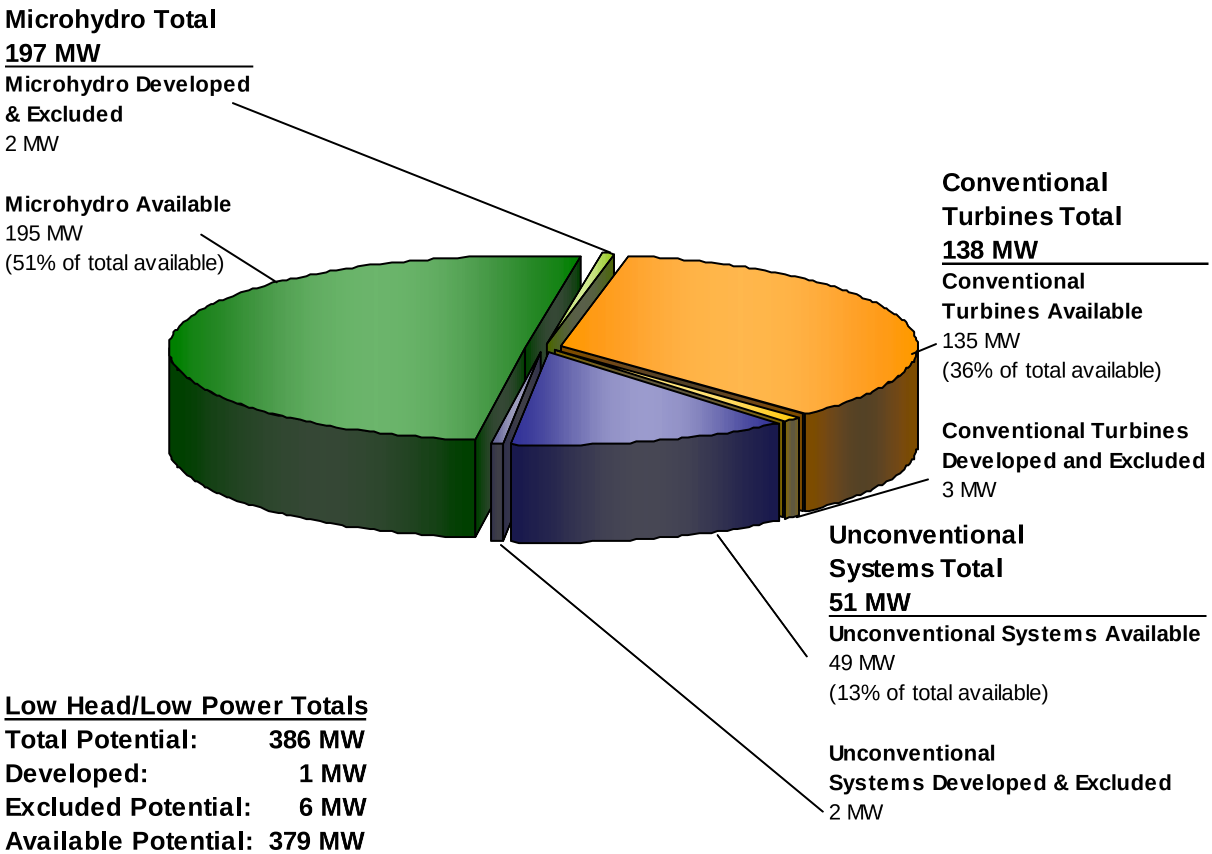


Figure B-74. Distribution of low head/low power hydropower potential in Kentucky among three low head/low power hydropower technology classes.

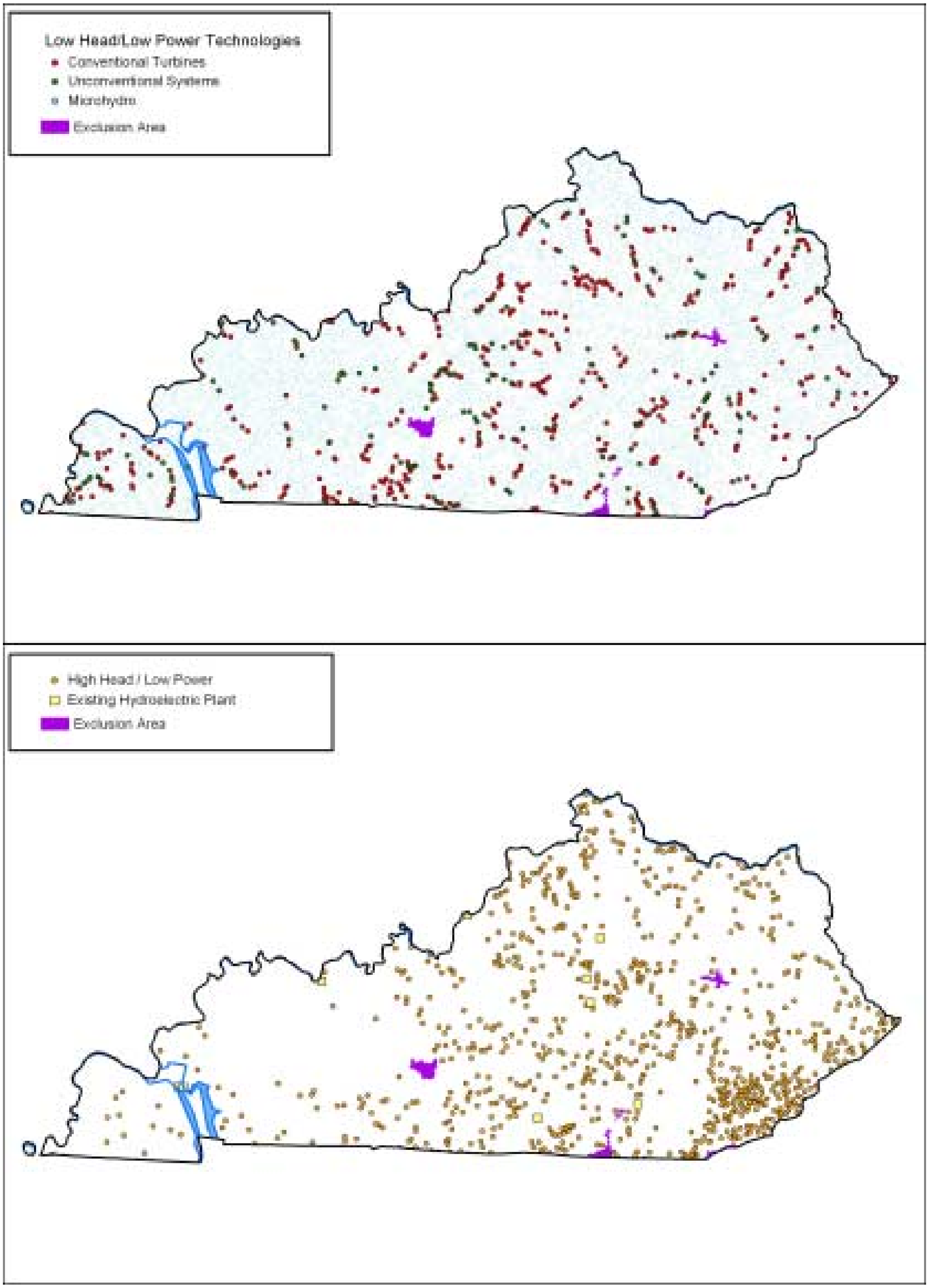


Figure B-75. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Kentucky.

B.16 Louisiana

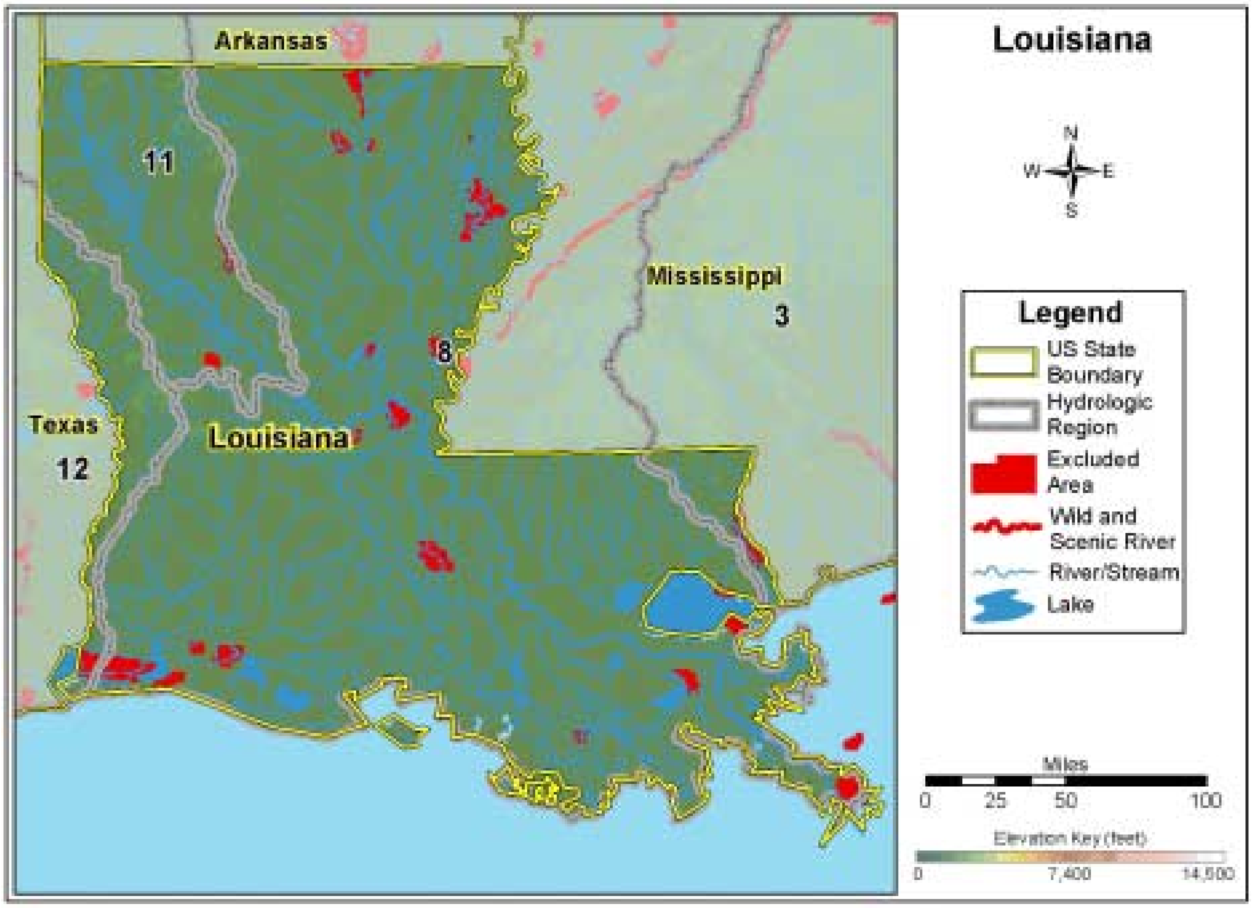


Figure B-76. Louisiana.

Table B-16. Summary of results of hydropower resource assessment of Louisiana.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**2,236**	**89**	**129**	**2,018**
TOTAL HIGH POWER	**1,974**	**89**	**121**	**1,764**
High Head/High Power	**10**	**0**	**0**	**10**
Low Head/High Power	**1,964**	**89**	**121**	**1,754**
TOTAL LOW POWER	**262**	**0**	**8**	**254**
High Head/Low Power	**11**	**0**	**0**	**11**
Low Head/Low Power	**251**	**0**	**8**	**243**
Conventional Turbine	69	0	1	68
Unconventional Systems	77	0	5	72
Microhydro	105	0	2	103

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

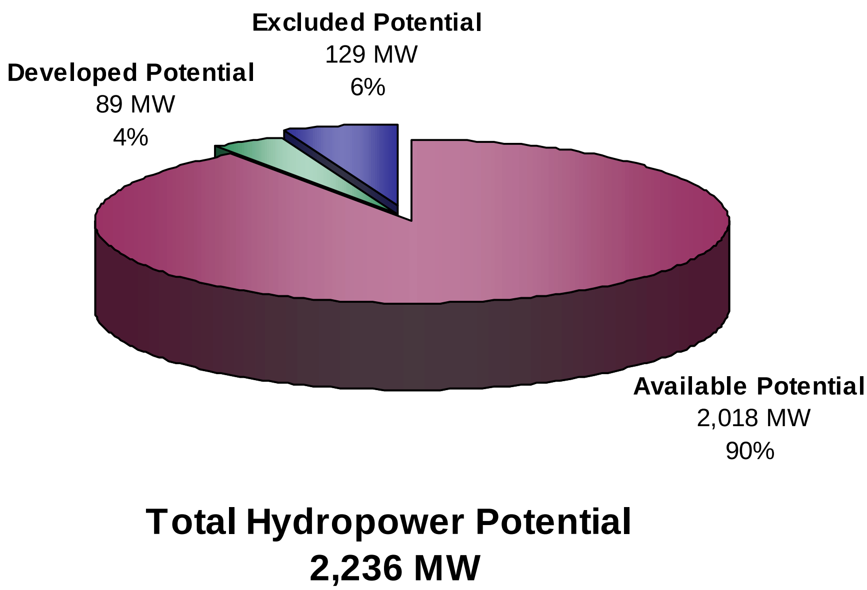


Figure B-77. Distribution of total hydropower potential in Louisiana.

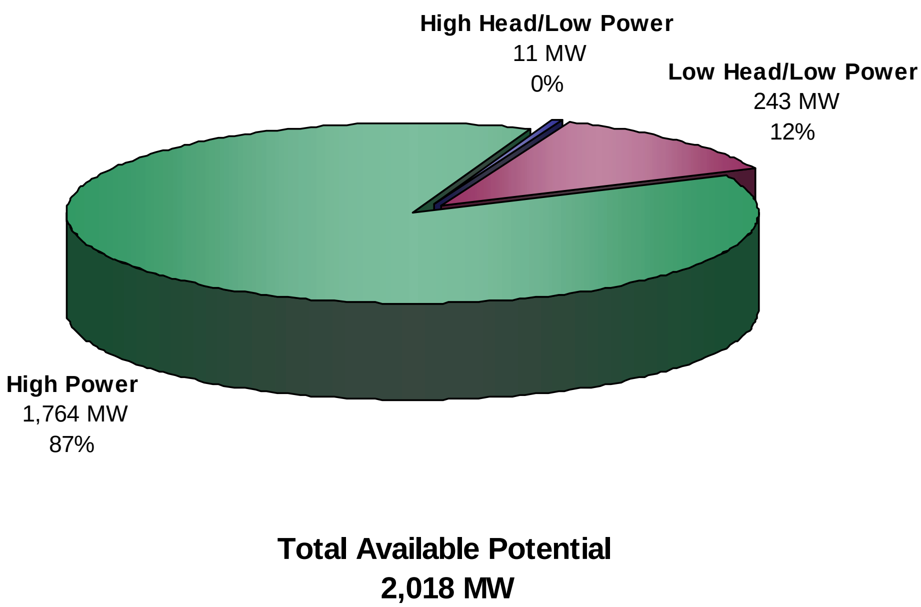


Figure B-78. Distribution of available hydropower potential in Louisiana.

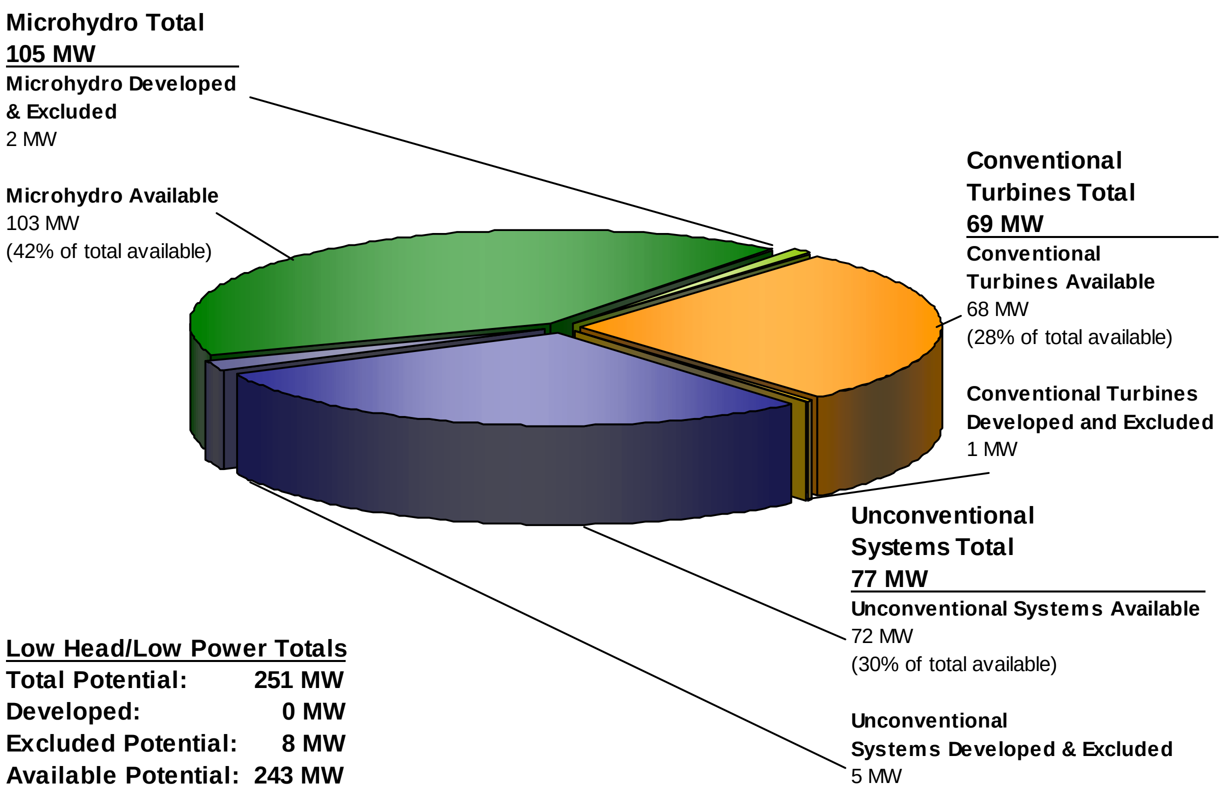


Figure B-79. Distribution of low head/low power hydropower potential in Louisiana among three low head/low power hydropower technology classes.

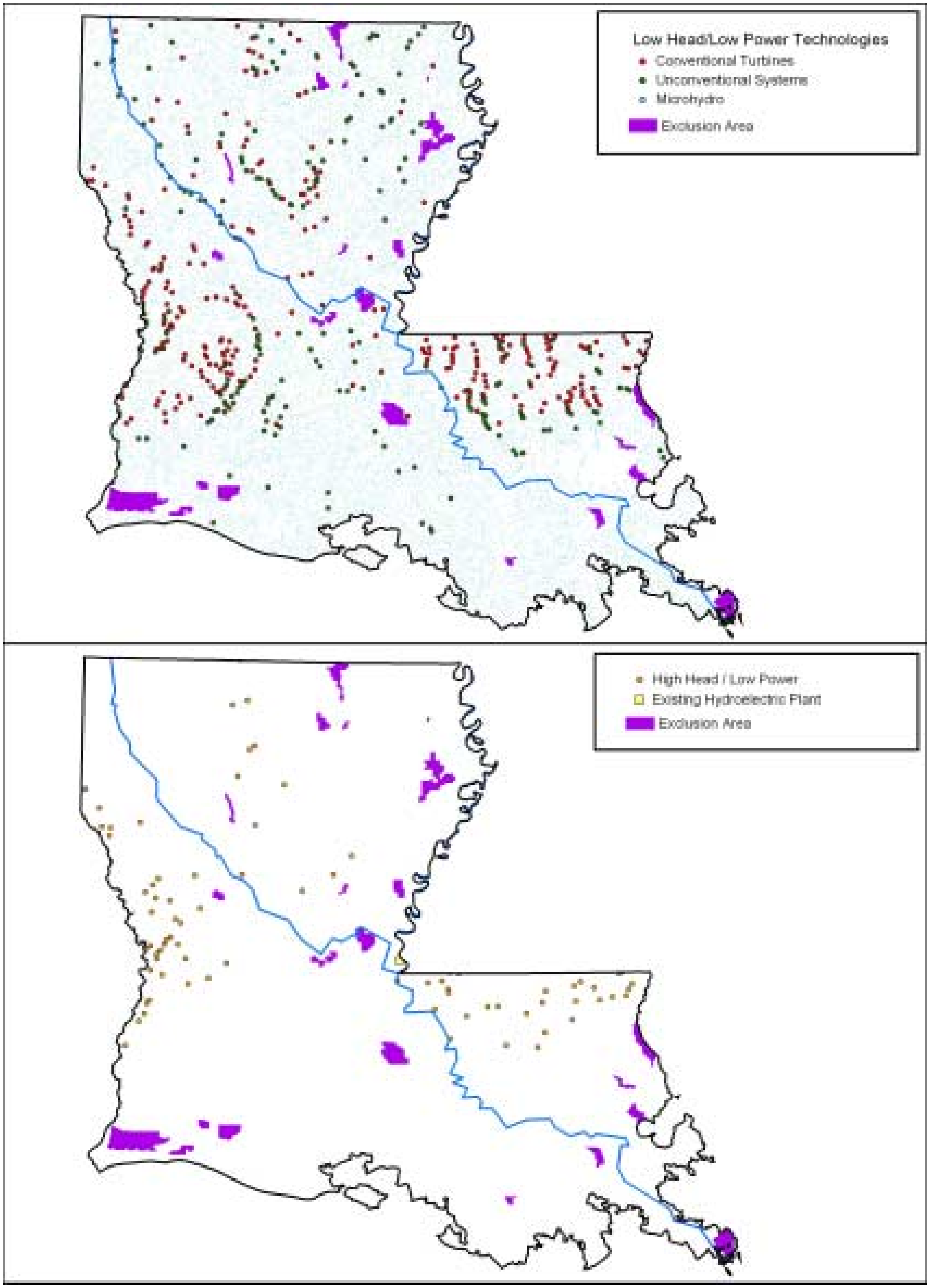


Figure B-80. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Louisiana.

B.17 Maine

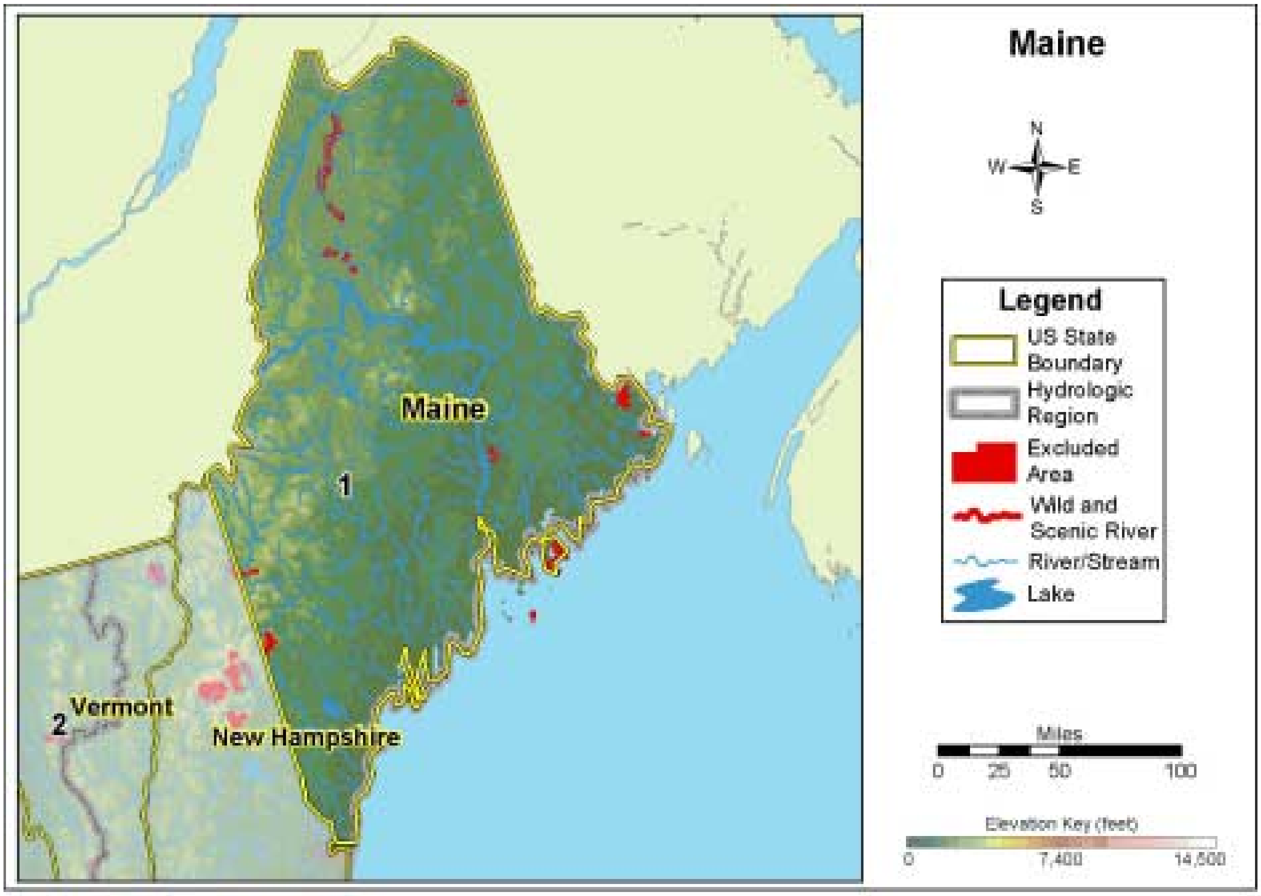


Figure B-81. Maine.

Table B-17. Summary of results of hydropower resource assessment of Maine.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**2,766**	**431**	**71**	**2,264**
TOTAL HIGH POWER	**1,968**	**422**	**43**	**1,503**
High Head/High Power	**1,353**	**304**	**26**	**1,023**
Low Head/High Power	**615**	**118**	**17**	**480**
TOTAL LOW POWER	**798**	**9**	**28**	**761**
High Head/Low Power	**488**	**1**	**16**	**471**
Low Head/Low Power	**310**	**8**	**12**	**290**
Conventional Turbine	119	7	3	109
Unconventional Systems	44	0	5	39
Microhydro	147	1	4	142

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

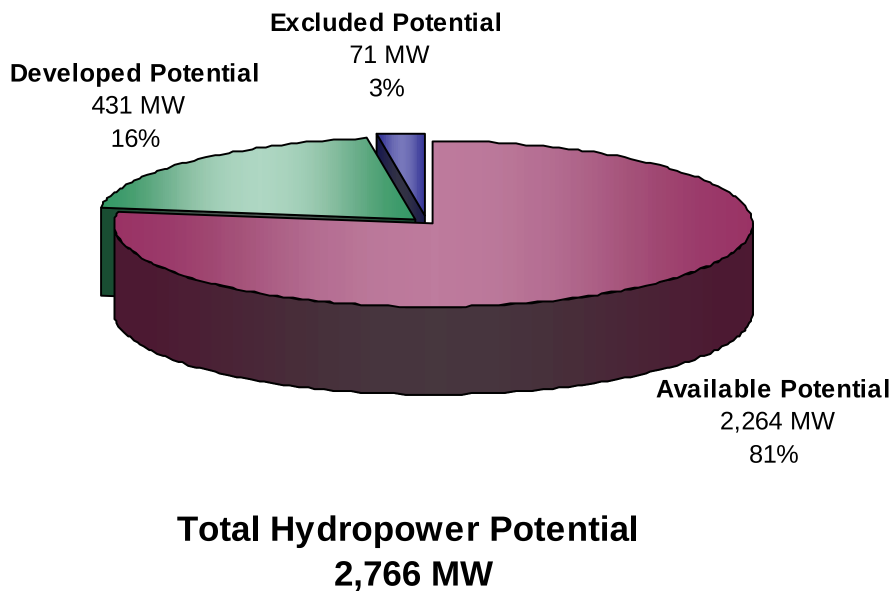


Figure B-82. Distribution of total hydropower potential in Maine.

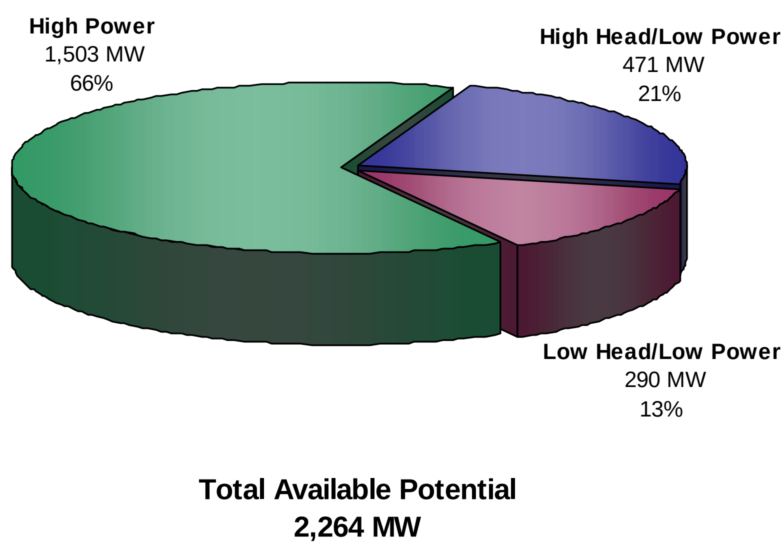


Figure B-83. Distribution of available hydropower potential in Maine.

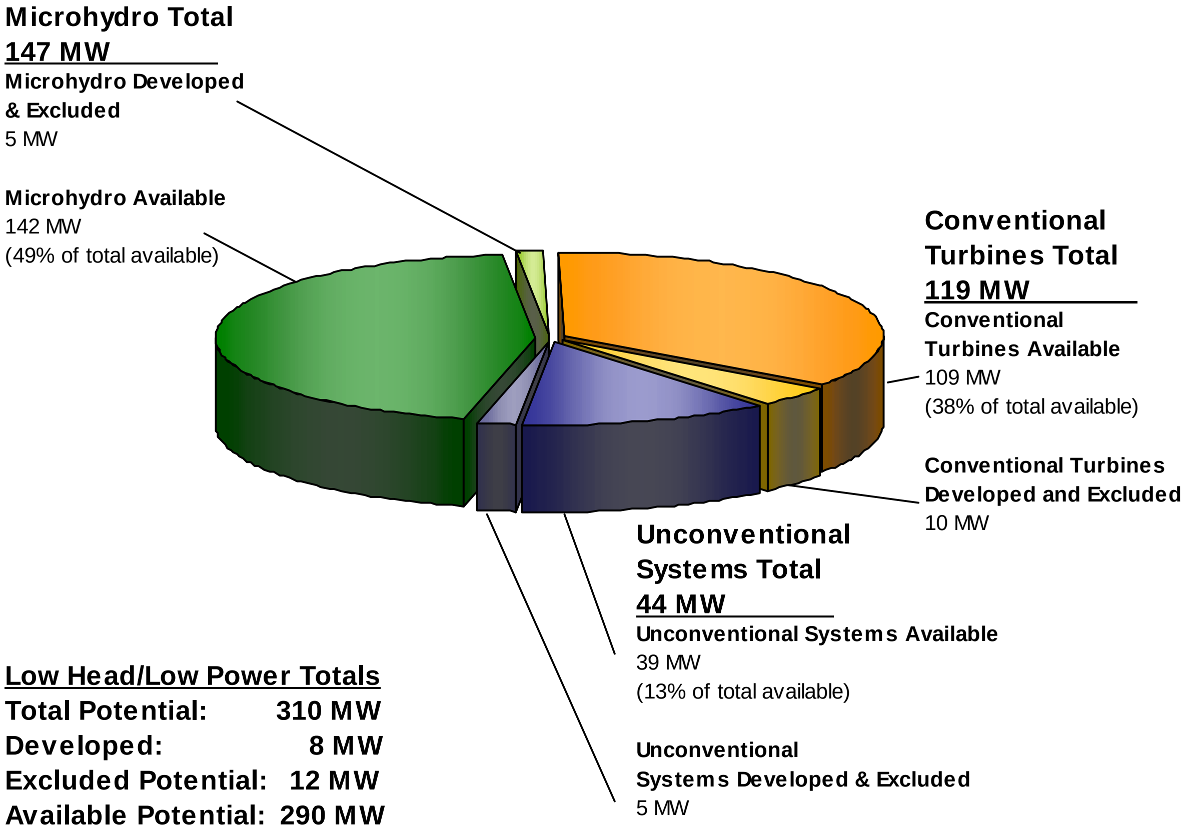


Figure B-84. Distribution of low head/low power hydropower potential in Maine among three low head/low power hydropower technology classes.

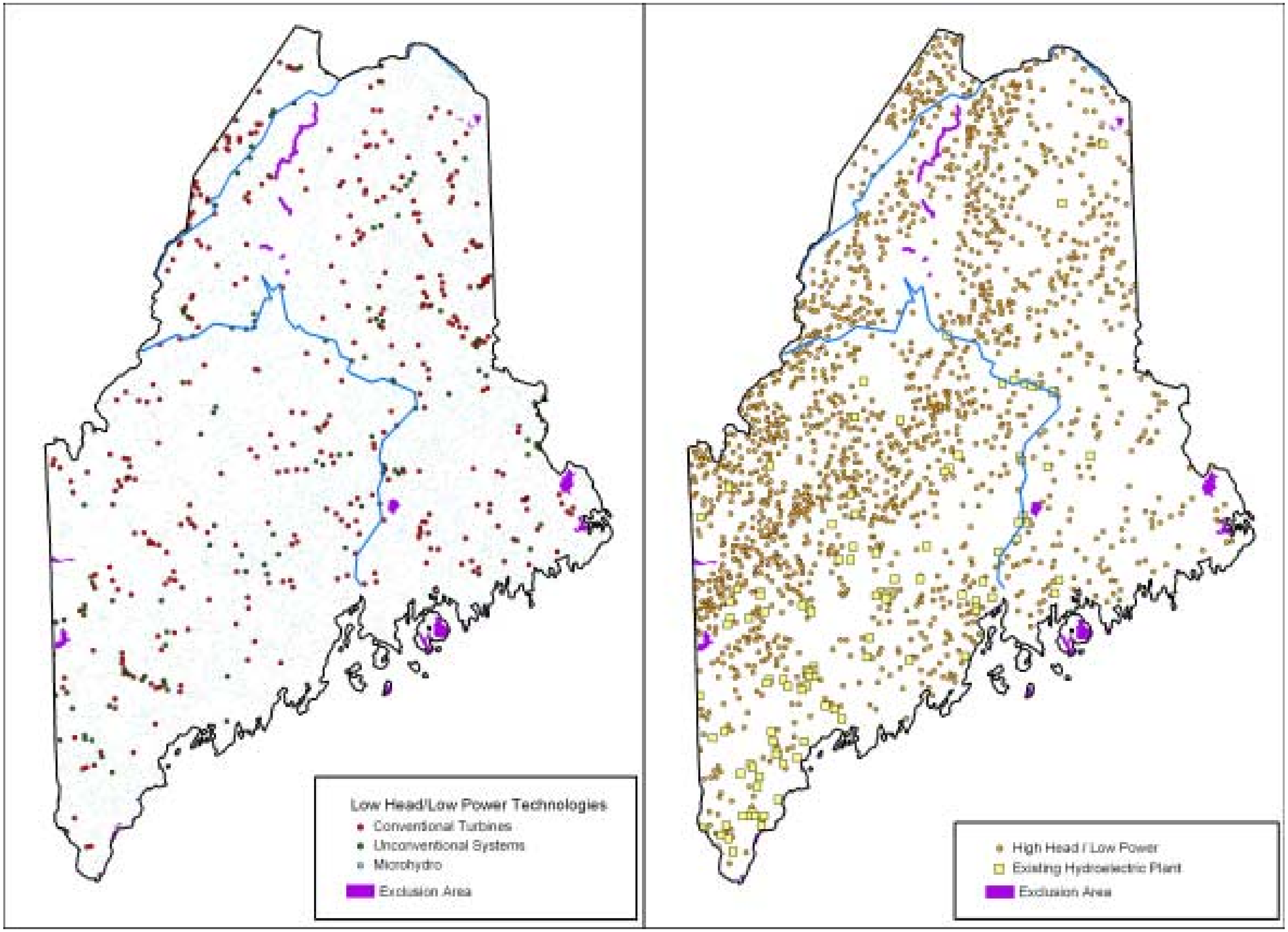


Figure B-85. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Maine.

B.18 Maryland

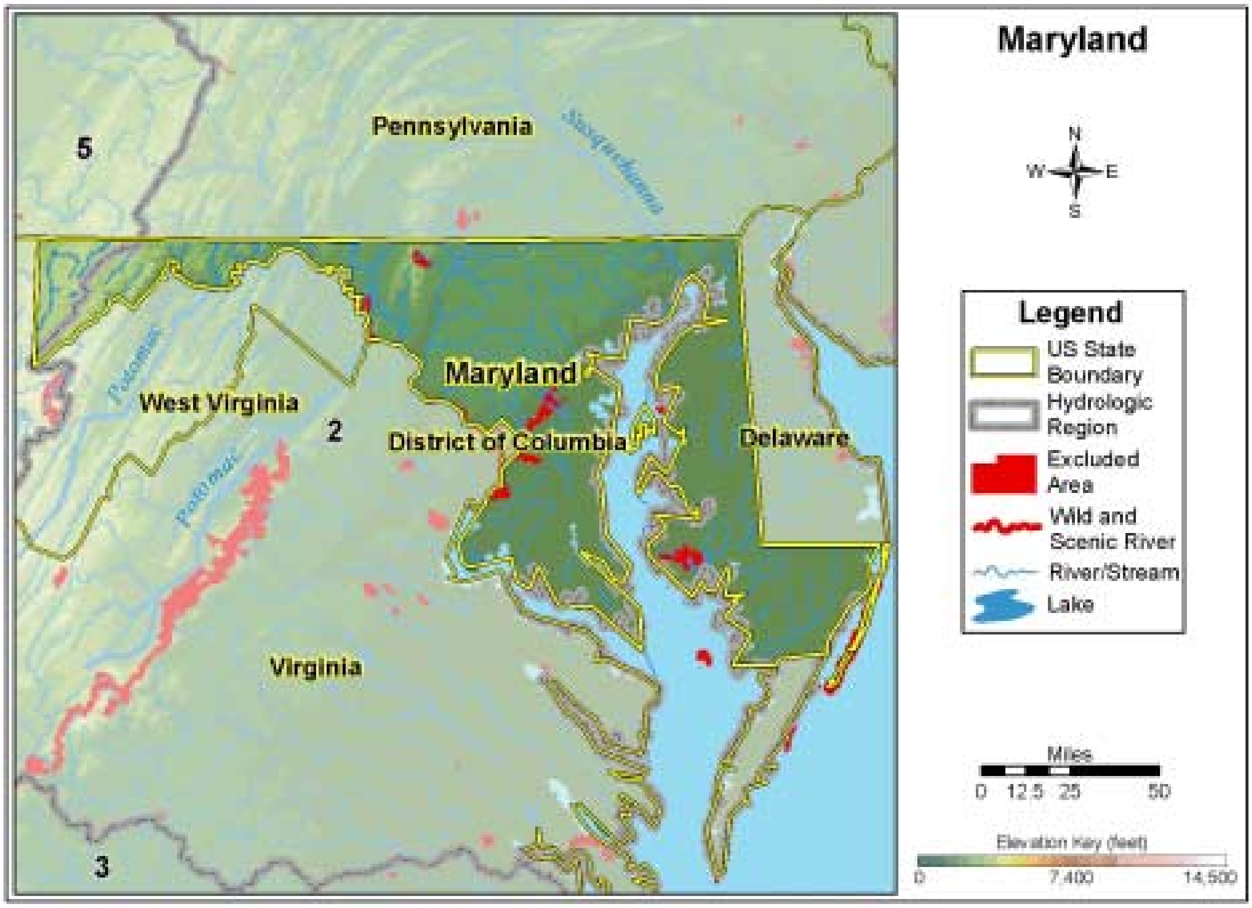


Figure B-86. Maryland.

Table B-18. Summary of results of hydropower resource assessment of Maryland.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**845**	**203**	**298**	**344**
TOTAL HIGH POWER	**695**	**202**	**282**	**211**
High Head/High Power	**521**	**202**	**145**	**174**
Low Head/High Power	**174**	**0**	**137**	**37**
TOTAL LOW POWER	**150**	**1**	**16**	**133**
High Head/Low Power	**83**	**1**	**8**	**74**
Low Head/Low Power	**67**	**0**	**8**	**59**
Conventional Turbine	26	0	5	21
Unconventional Systems	4	0	1	3
Microhydro	37	0	2	35

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

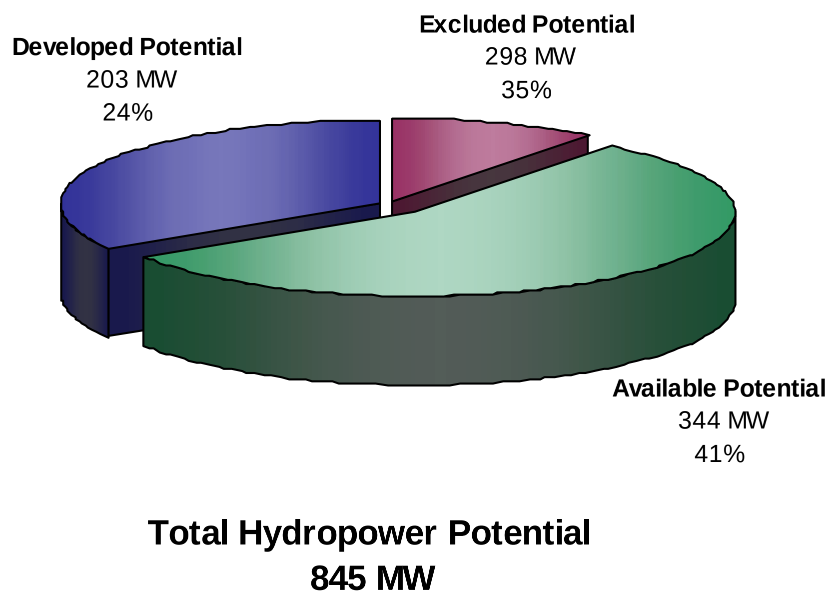


Figure B-87. Distribution of total hydropower potential in Maryland.

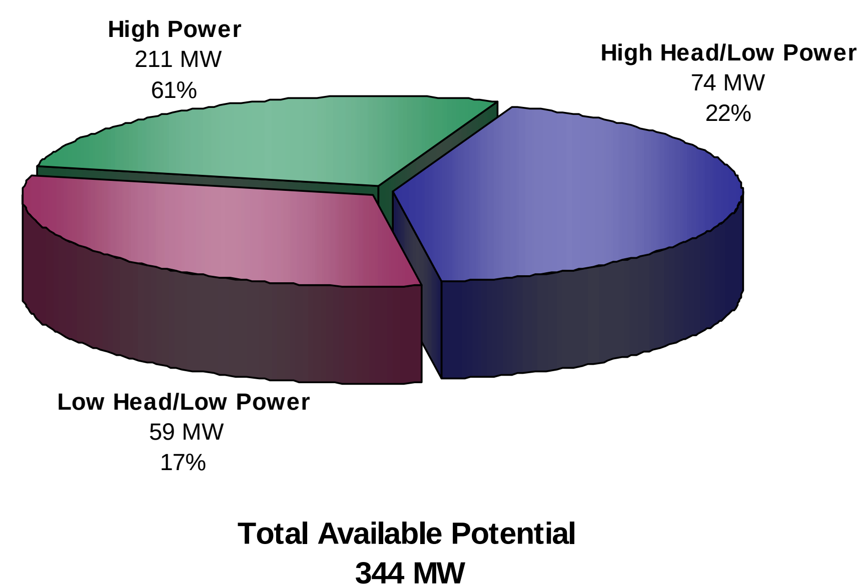


Figure B-88. Distribution of available hydropower potential in Maryland.

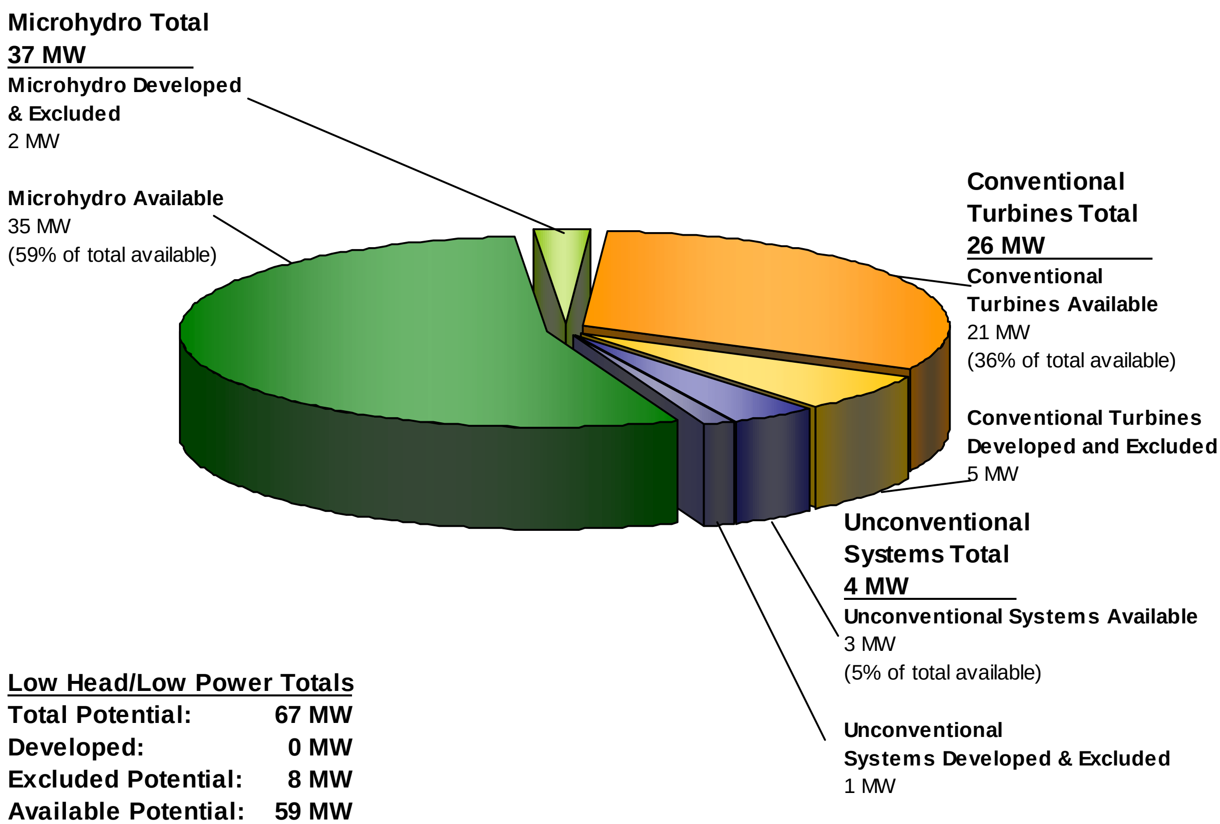


Figure B-89. Distribution of low head/low power hydropower potential in Maryland among three low head/low power hydropower technology classes.

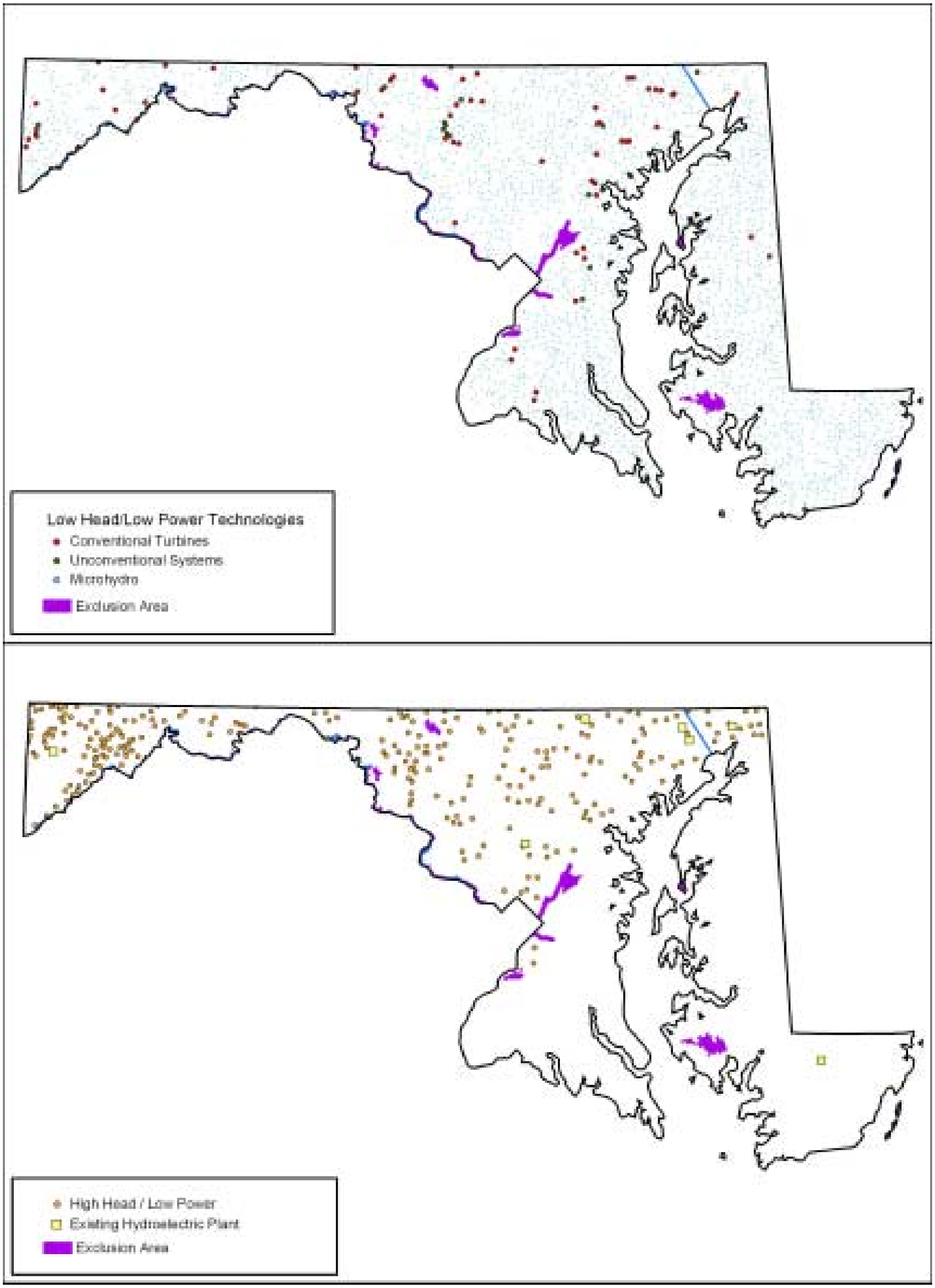


Figure B-90. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Maryland.

B.19 Massachusetts

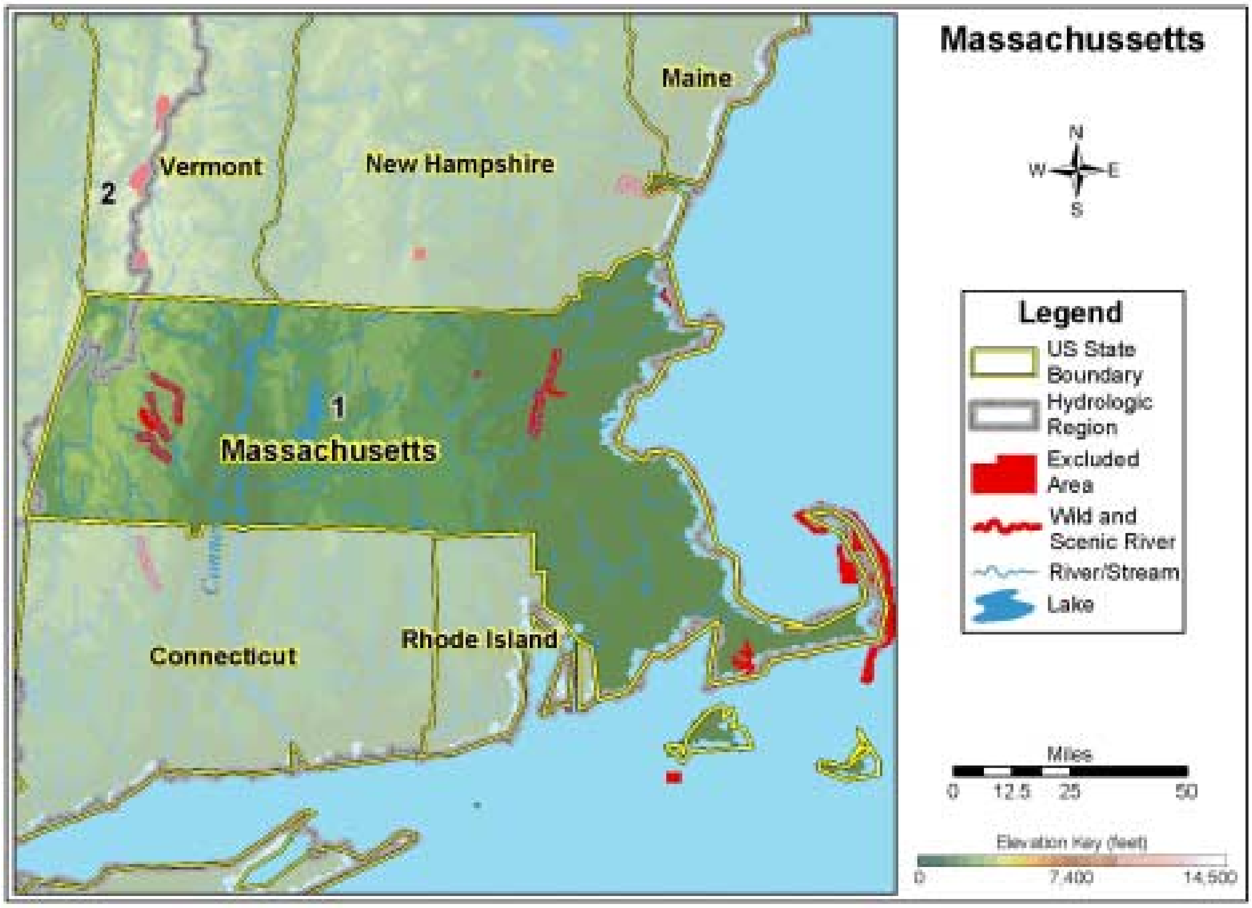


Figure B-91. Massachusetts.

Table B-19. Summary of results of hydropower resource assessment of Massachusetts.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**675**	**126**	**29**	**520**
TOTAL HIGH POWER	**478**	**118**	**11**	**349**
High Head/High Power	**377**	**113**	**11**	**253**
Low Head/High Power	**101**	**5**	**0**	**96**
TOTAL LOW POWER	**197**	**8**	**18**	**171**
High Head/Low Power	**127**	**3**	**15**	**109**
Low Head/Low Power	**70**	**5**	**3**	**62**
Conventional Turbine	28	5	2	21
Unconventional Systems	6	0	0	6
Microhydro	36	0	1	35

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

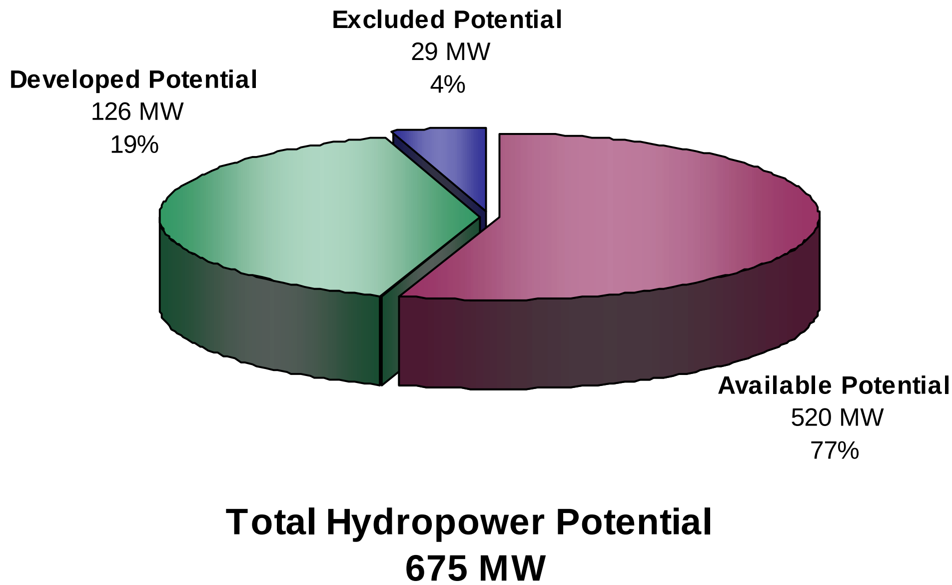


Figure B-92. Distribution of total hydropower potential in Massachusetts.

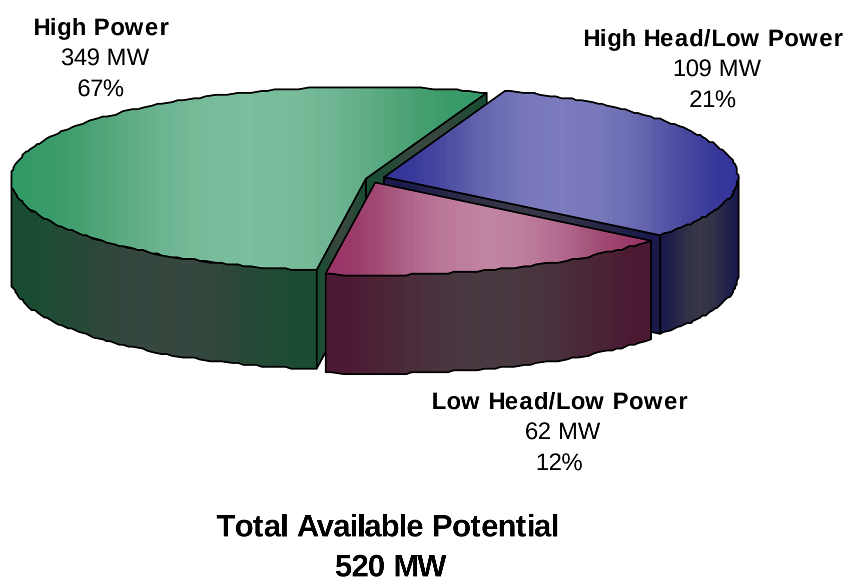


Figure B-93. Distribution of available hydropower potential in Massachusetts.

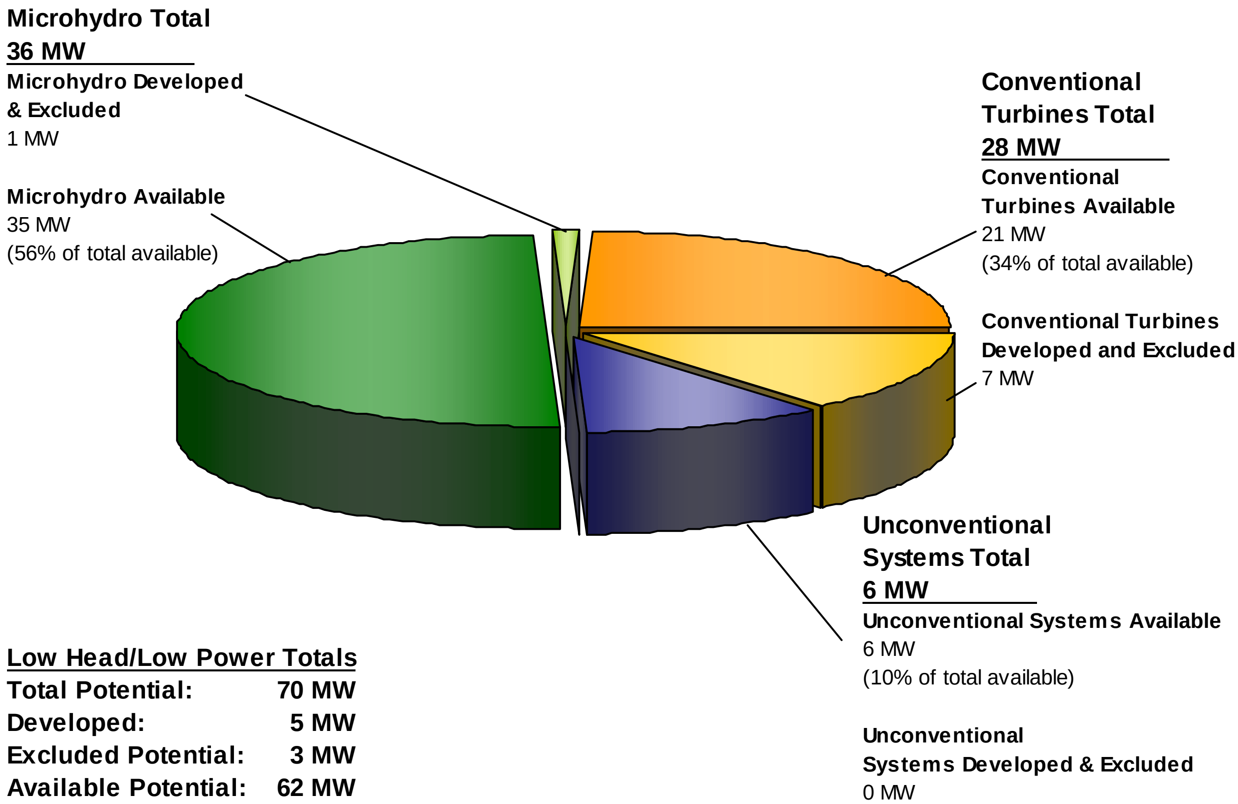


Figure B-94. Distribution of low head/low power hydropower potential in Massachusetts among three low head/low power hydropower technology classes.

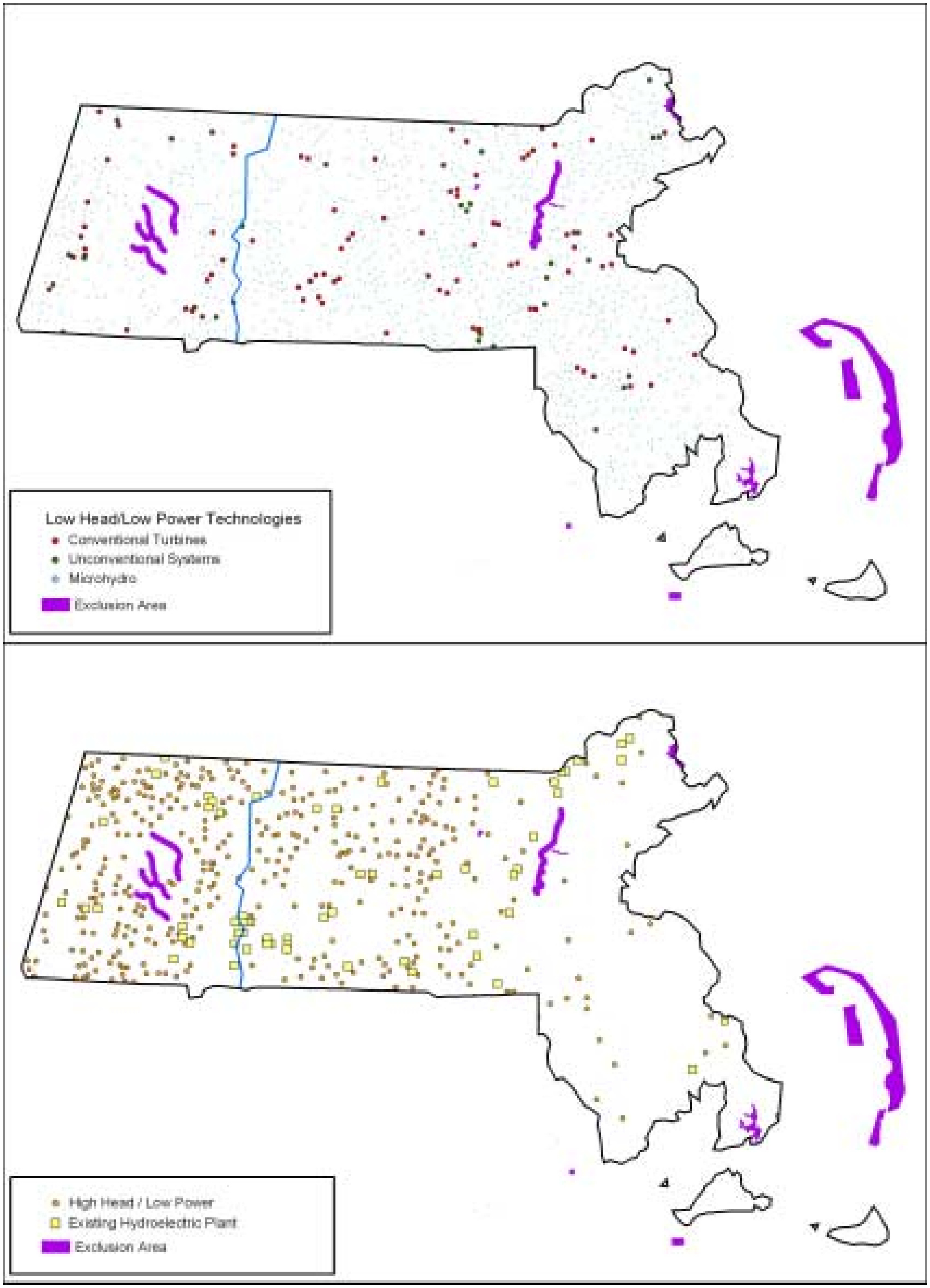


Figure B-95. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Massachusetts.

B.20 Michigan

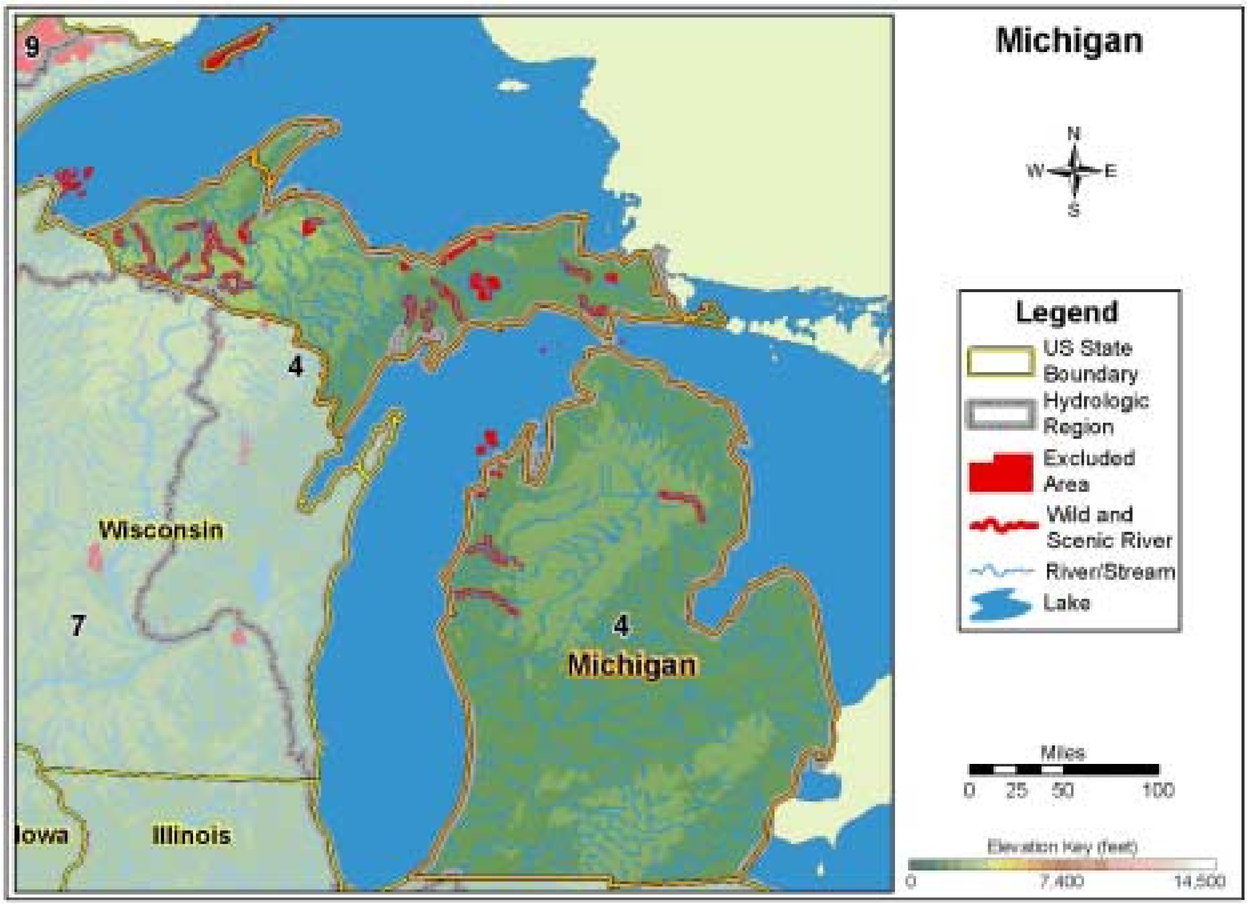


Figure B-96. Michigan.

Table B-20. Summary of results of hydropower resource assessment of Michigan.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,220**	**209**	**224**	**787**
TOTAL HIGH POWER	**520**	**201**	**140**	**179**
High Head/High Power	**360**	**109**	**122**	**129**
Low Head/High Power	**160**	**92**	**18**	**50**
TOTAL LOW POWER	**700**	**8**	**84**	**608**
High Head/Low Power	**223**	**1**	**34**	**188**
Low Head/Low Power	**477**	**7**	**50**	**420**
Conventional Turbine	193	7	27	159
Unconventional Systems	60	0	9	51
Microhydro	224	0	14	210

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

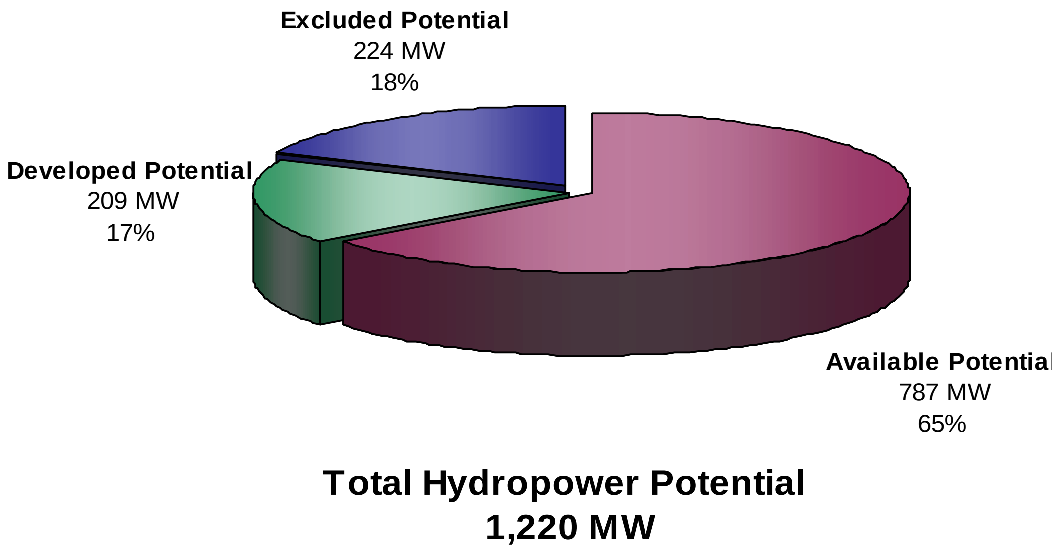


Figure B-97. Distribution of total hydropower potential in Michigan.

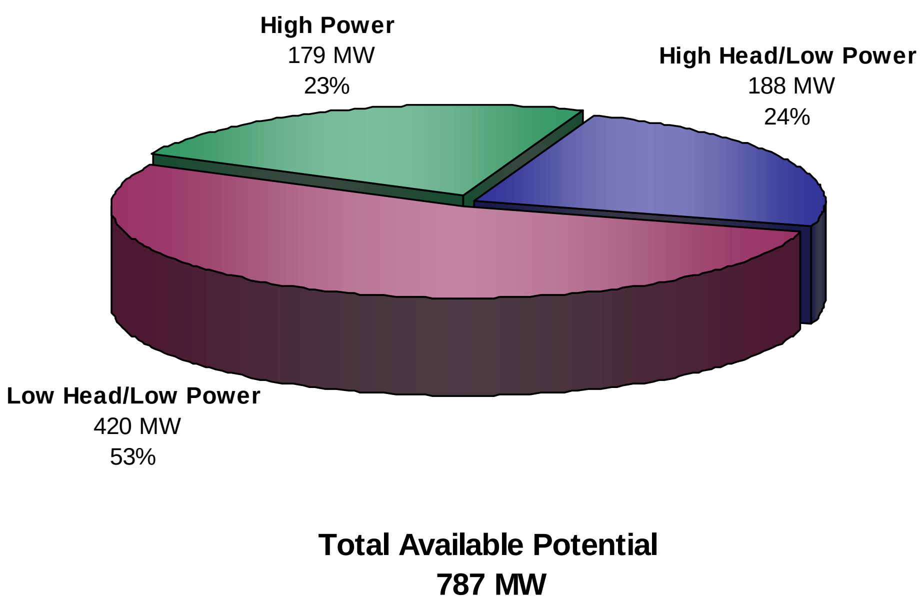


Figure B-98. Distribution of available hydropower potential in Michigan.

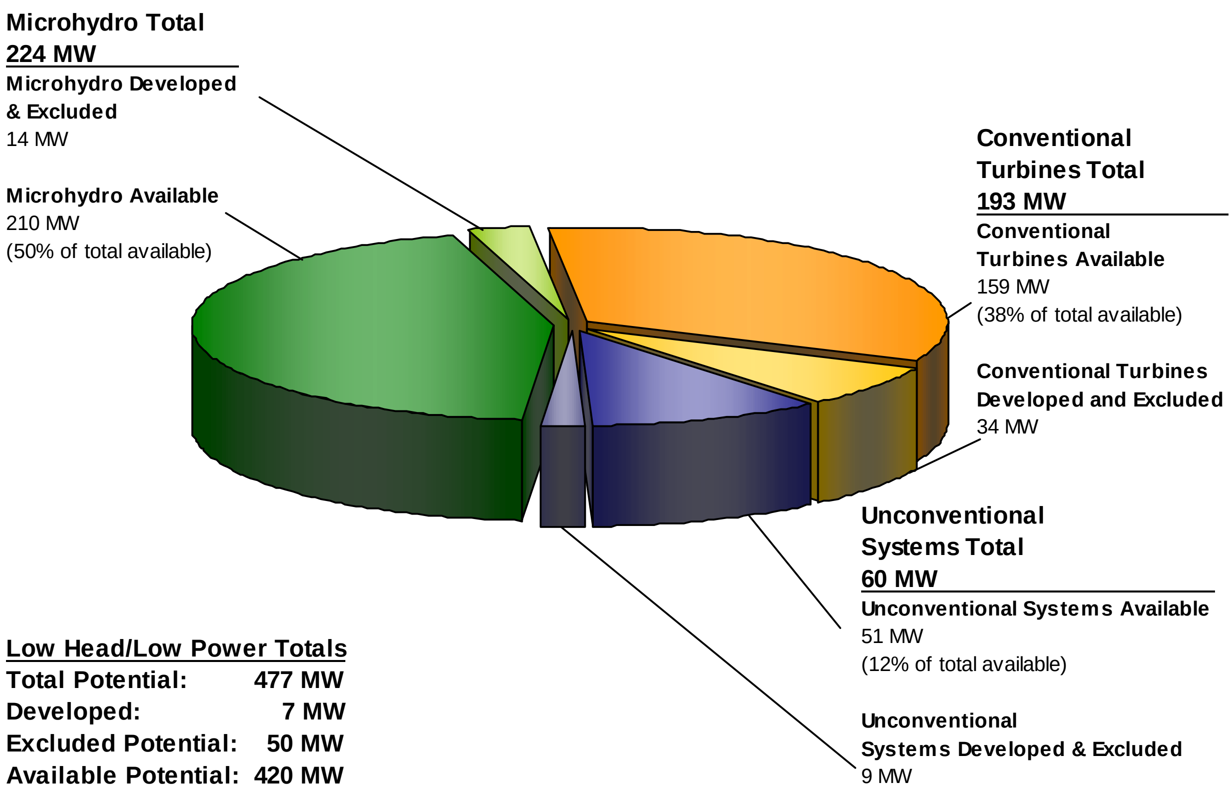


Figure B-99. Distribution of low head/low power hydropower potential in Michigan among three low head/low power hydropower technology classes.

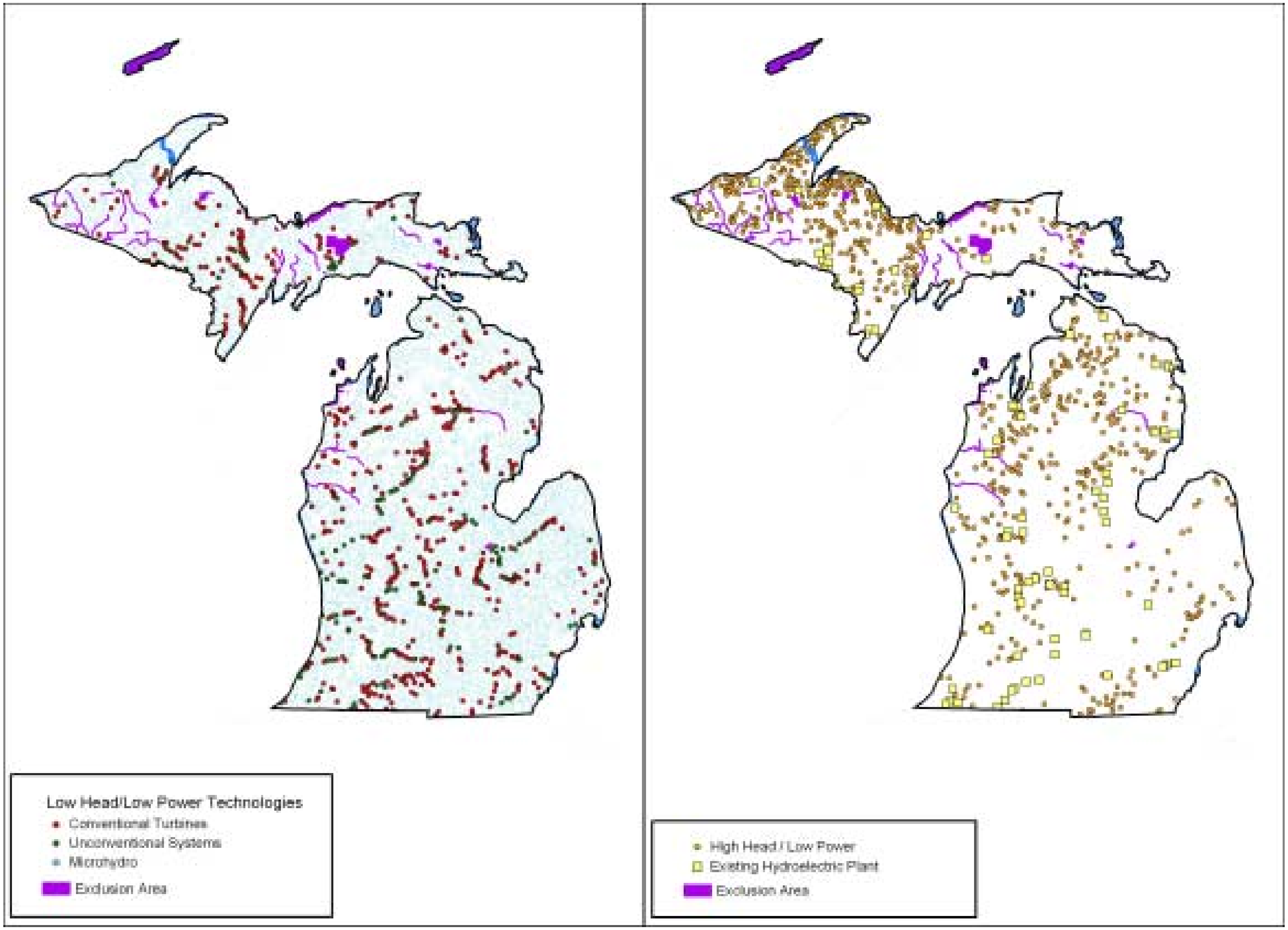


Figure B-100. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Michigan.

B.21 Minnesota

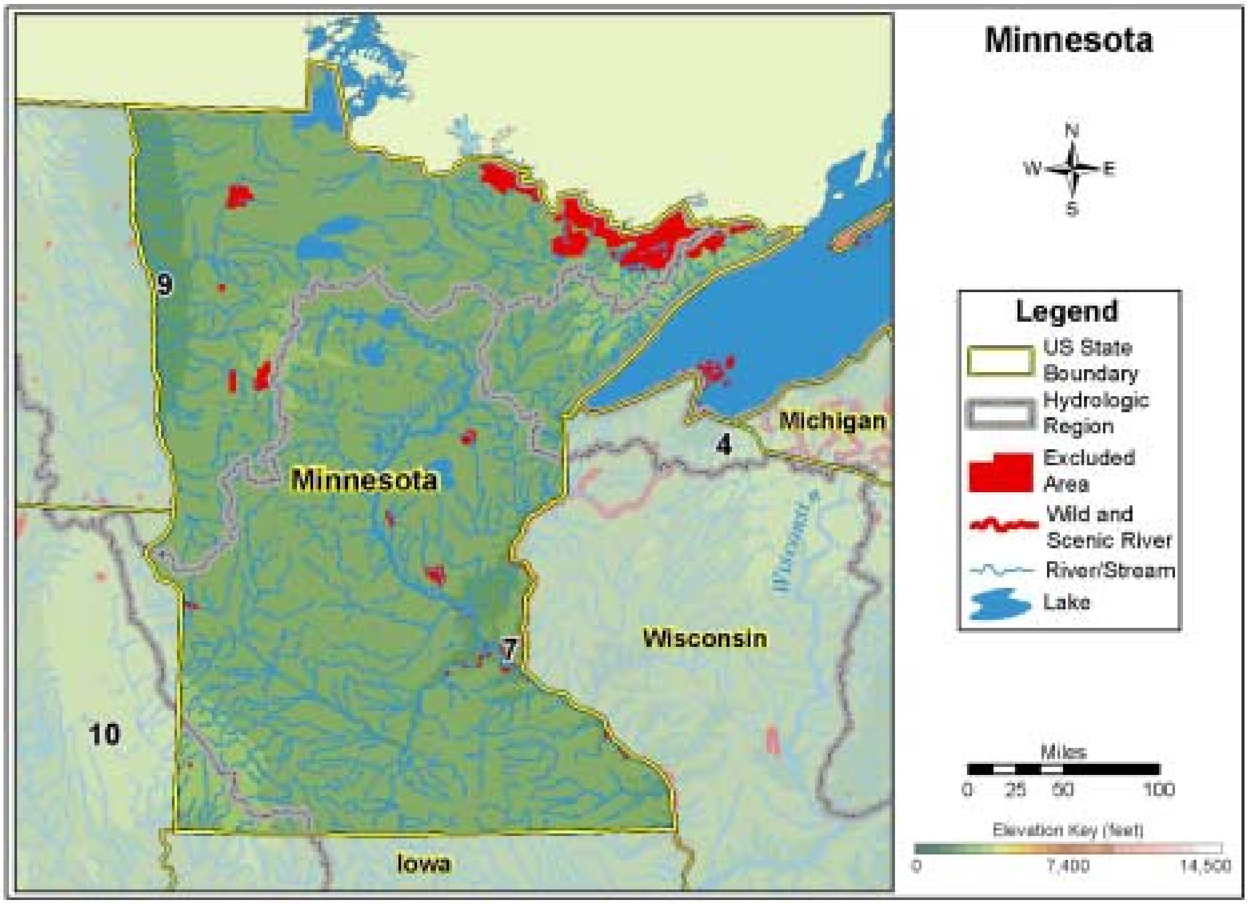


Figure B-101. Minnesota.

Table B-21. Summary of results of hydropower resource assessment of Minnesota.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,410**	**128**	**249**	**1,033**
TOTAL HIGH POWER	**760**	**125**	**192**	**443**
High Head/High Power	**409**	**103**	**73**	**233**
Low Head/High Power	**351**	**22**	**119**	**210**
TOTAL LOW POWER	**650**	**3**	**57**	**590**
High Head/Low Power	**196**	**1**	**27**	**168**
Low Head/Low Power	**454**	**2**	**30**	**422**
Conventional Turbine	152	2	11	139
Unconventional Systems	78	0	6	72
Microhydro	224	0	13	211

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

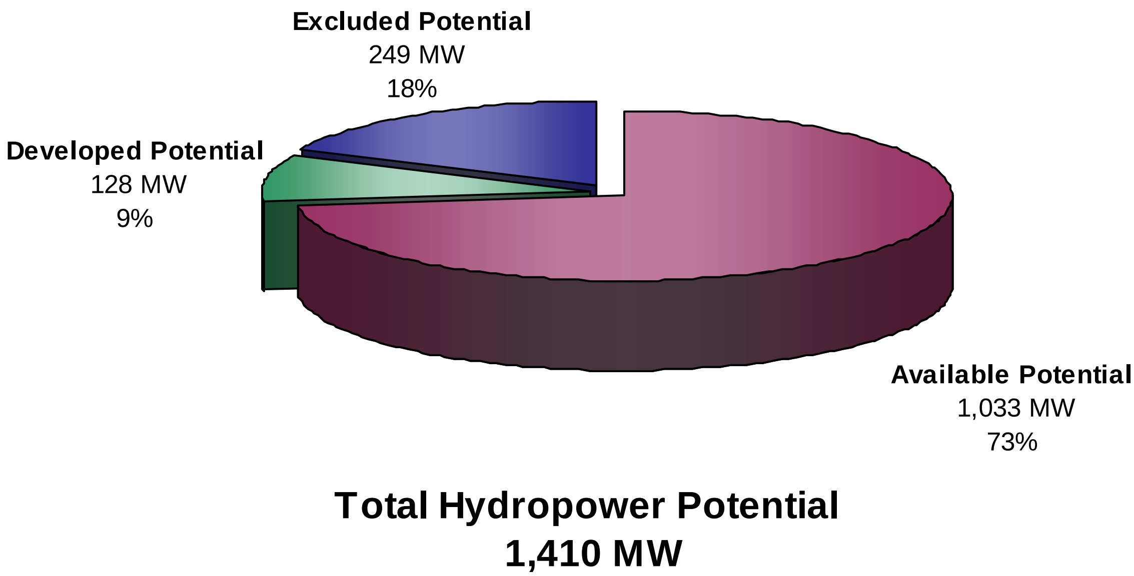


Figure B-102. Distribution of total hydropower potential in Minnesota.

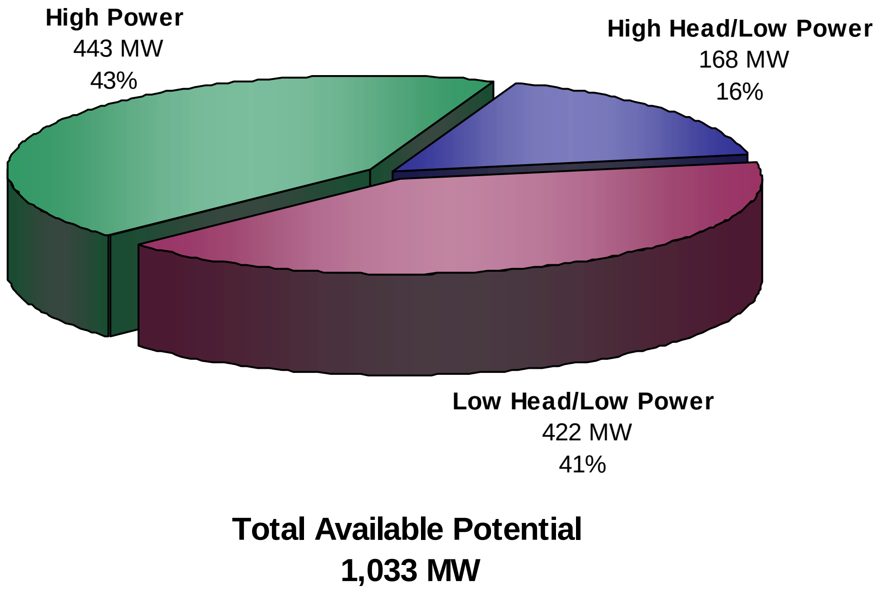


Figure B-103. Distribution of available hydropower potential in Minnesota.

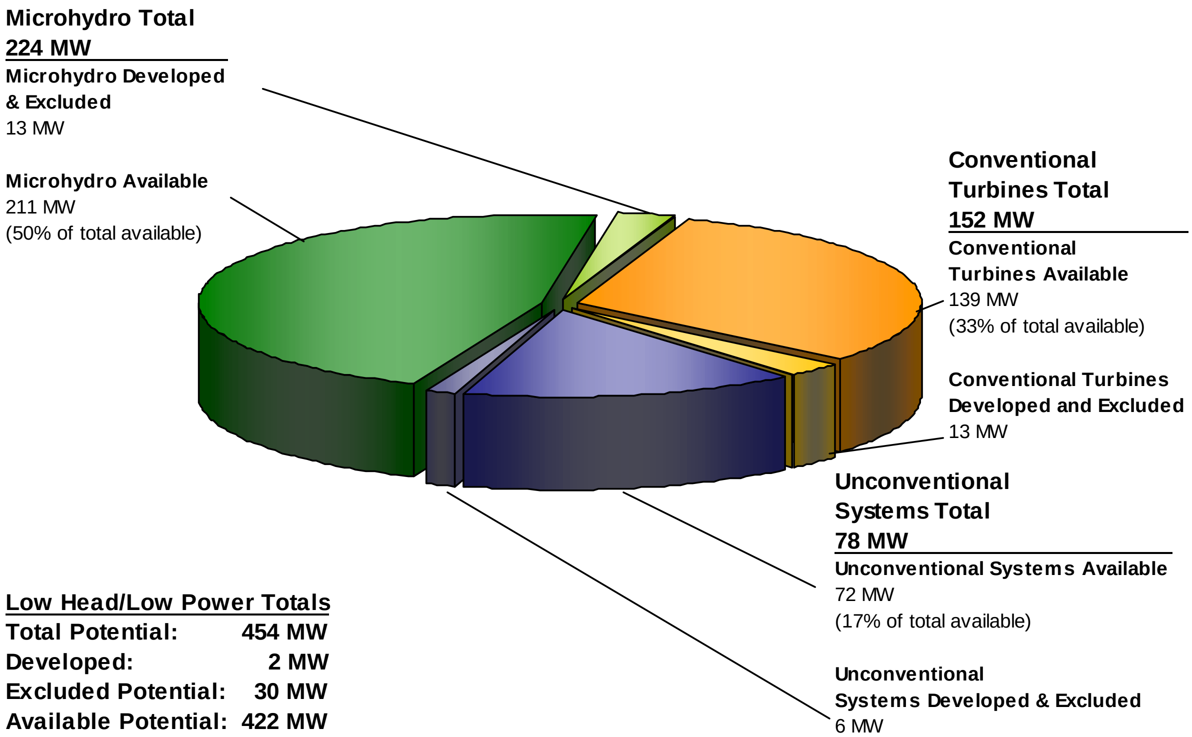


Figure B-104. Distribution of low head/low power hydropower potential in Minnesota among three low head/low power hydropower technology classes.

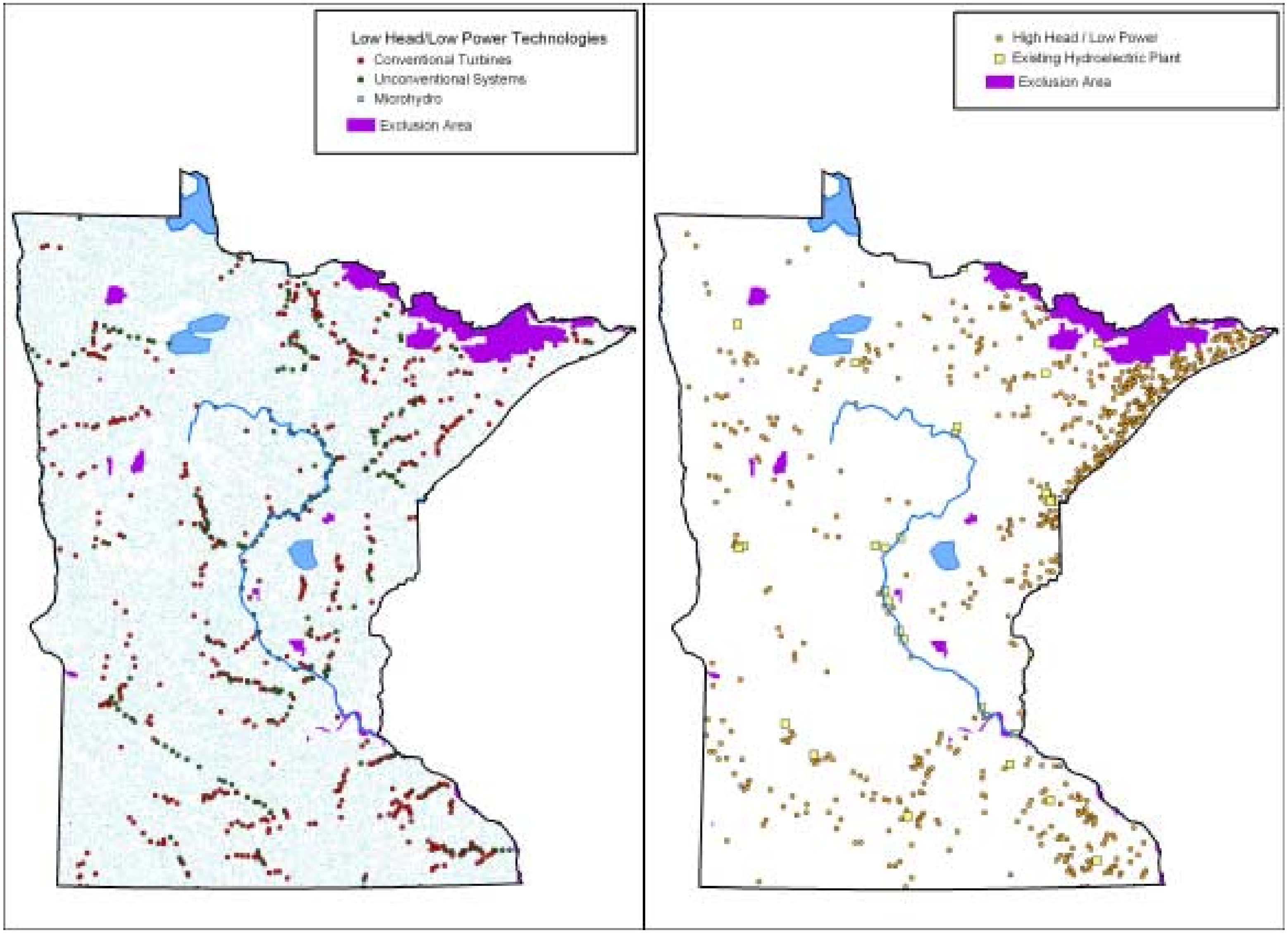


Figure B-105. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Minnesota.

B.22 Mississippi

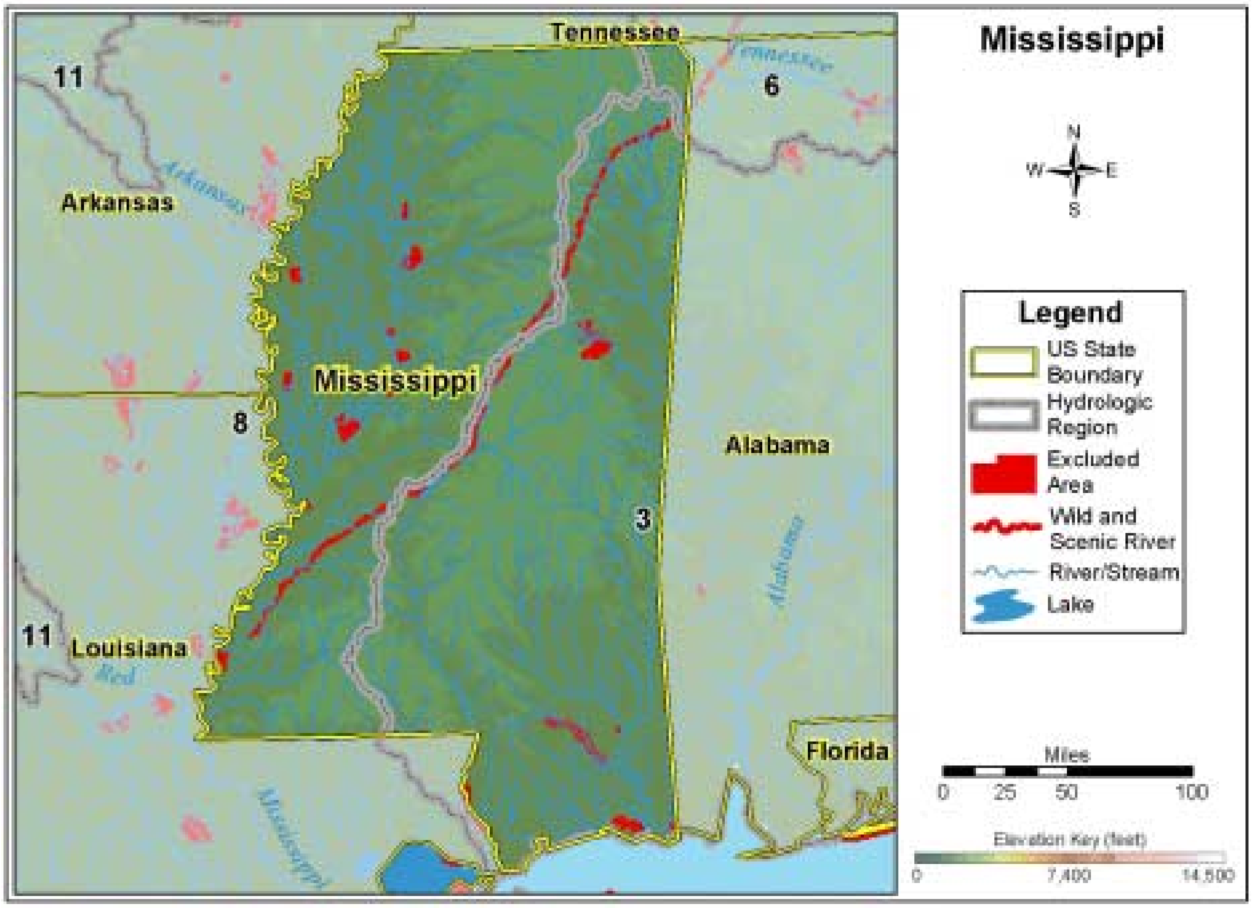


Figure B-106. Mississippi.

Table B-22. Summary of results of hydropower resource assessment of Mississippi.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**4,496**	**0**	**450**	**4,046**
TOTAL HIGH POWER	**3,899**	**0**	**422**	**3,477**
High Head/High Power	**62**	**0**	**2**	**60**
Low Head/High Power	**3,837**	**0**	**420**	**3,417**
TOTAL LOW POWER	**597**	**0**	**28**	**569**
High Head/Low Power	**63**	**0**	**2**	**61**
Low Head/Low Power	**534**	**0**	**26**	**508**
Conventional Turbine	184	0	12	172
Unconventional Systems	133	0	6	127
Microhydro	217	0	8	209

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

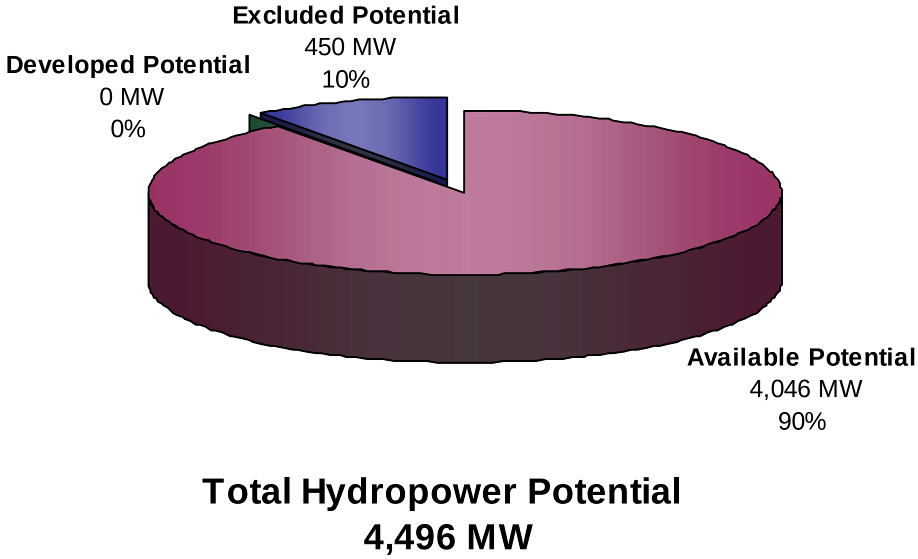


Figure B-107. Distribution of total hydropower potential in Mississippi.

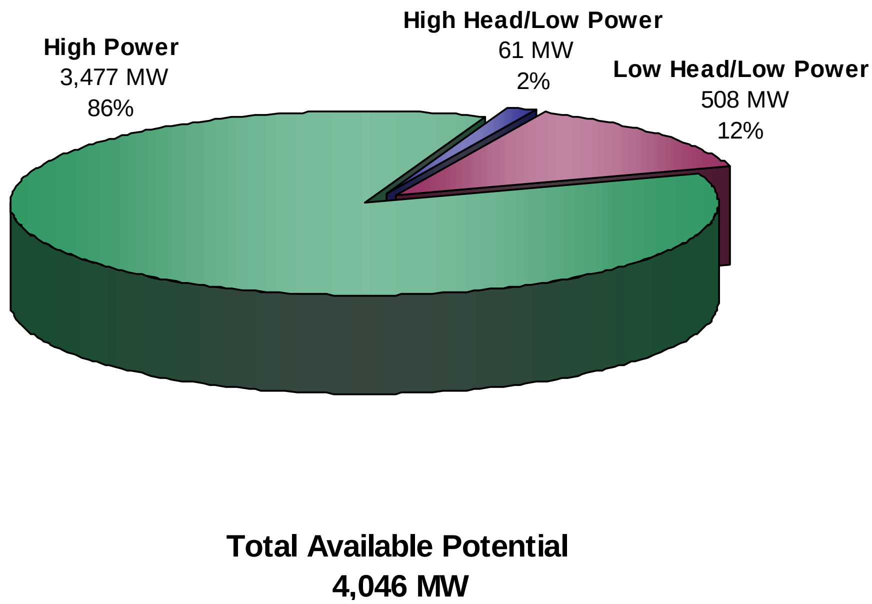


Figure B-108. Distribution of available hydropower potential in Mississippi.

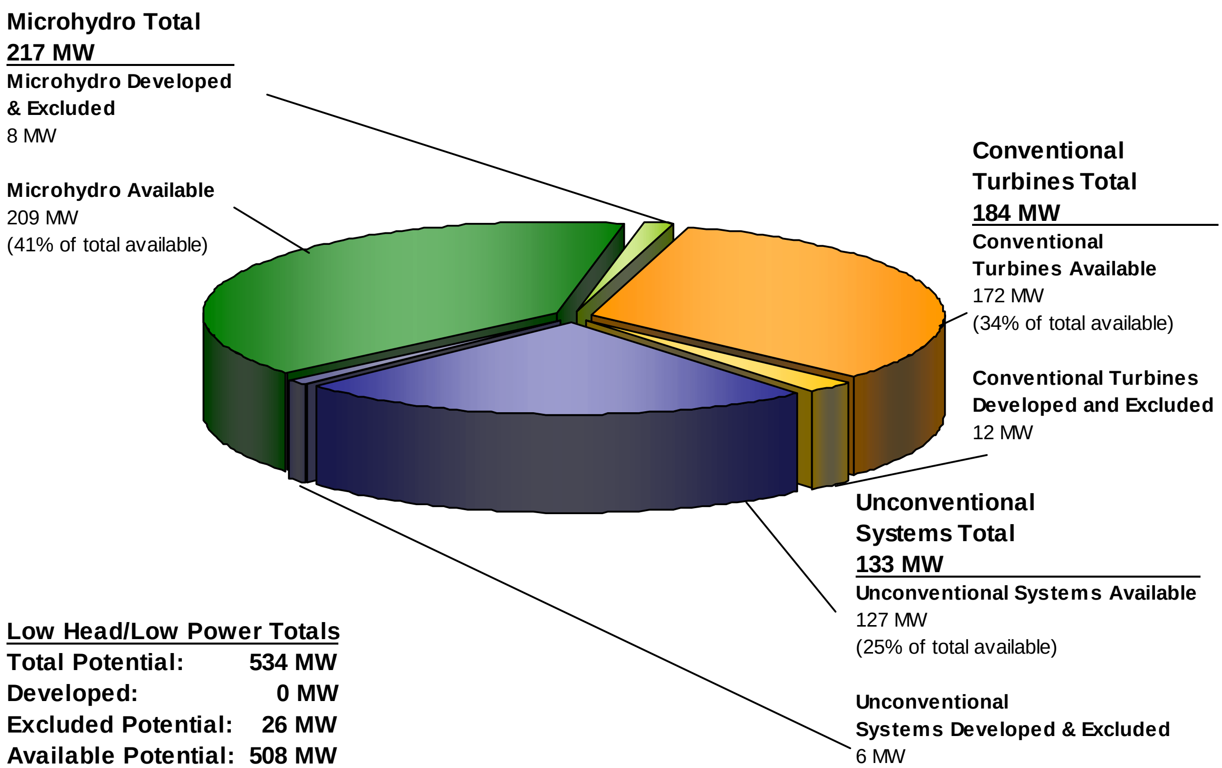


Figure B-109. Distribution of low head/low power hydropower potential in Mississippi among three low head/low power hydropower technology classes.

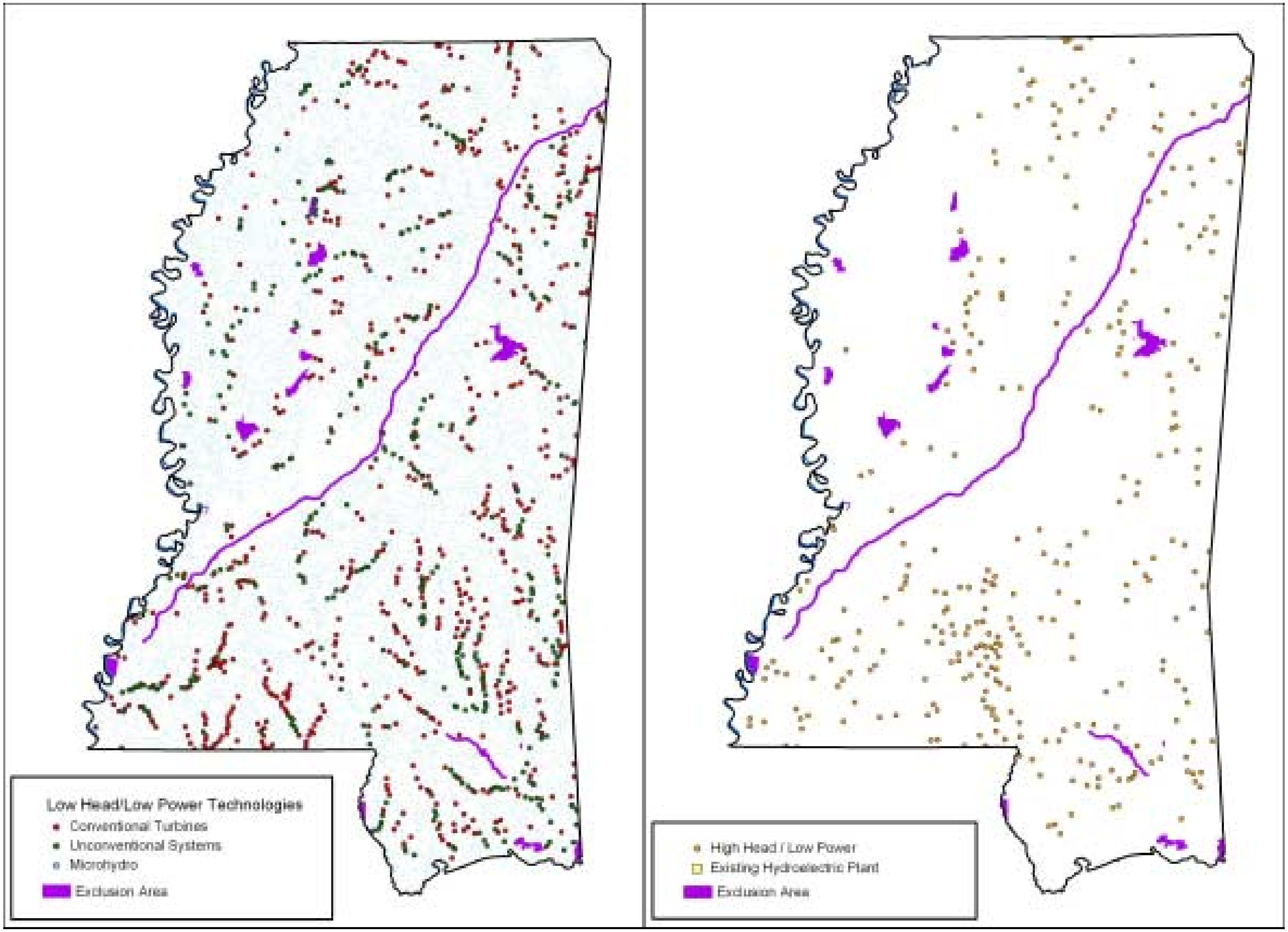


Figure B-110. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Mississippi.

B.23 Missouri

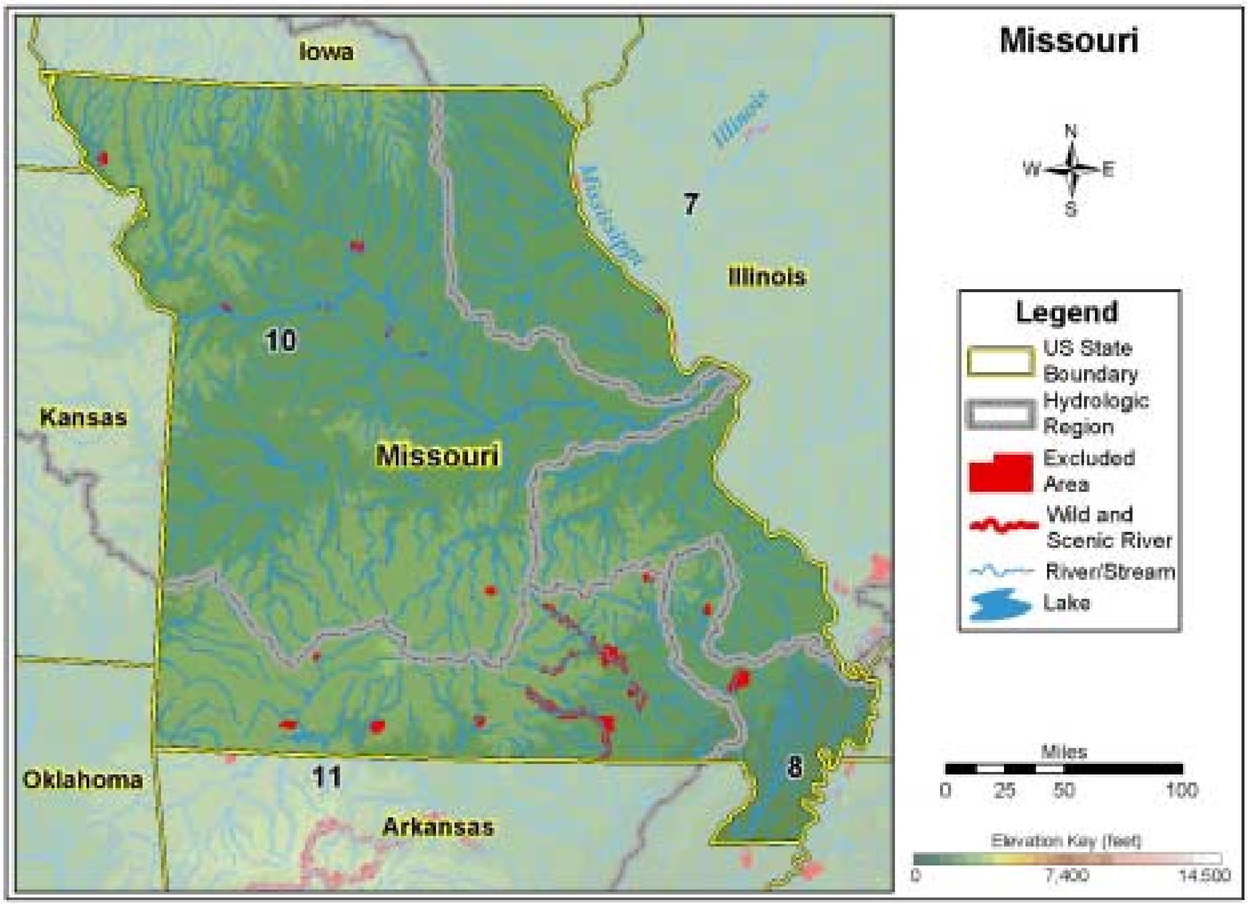


Figure B-111. Missouri.

Table B-23. Summary of results of hydropower resource assessment of Missouri.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**4,549**	**129**	**117**	**4,303**
TOTAL HIGH POWER	**3,588**	**129**	**65**	**3,394**
High Head/High Power	**190**	**129**	**14**	**47**
Low Head/High Power	**3,398**	**0**	**51**	**3,347**
TOTAL LOW POWER	**961**	**0**	**52**	**909**
High Head/Low Power	**202**	**0**	**16**	**186**
Low Head/Low Power	**759**	**0**	**36**	**723**
Conventional Turbine	296	0	19	277
Unconventional Systems	108	0	10	98
Microhydro	355	0	7	348

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

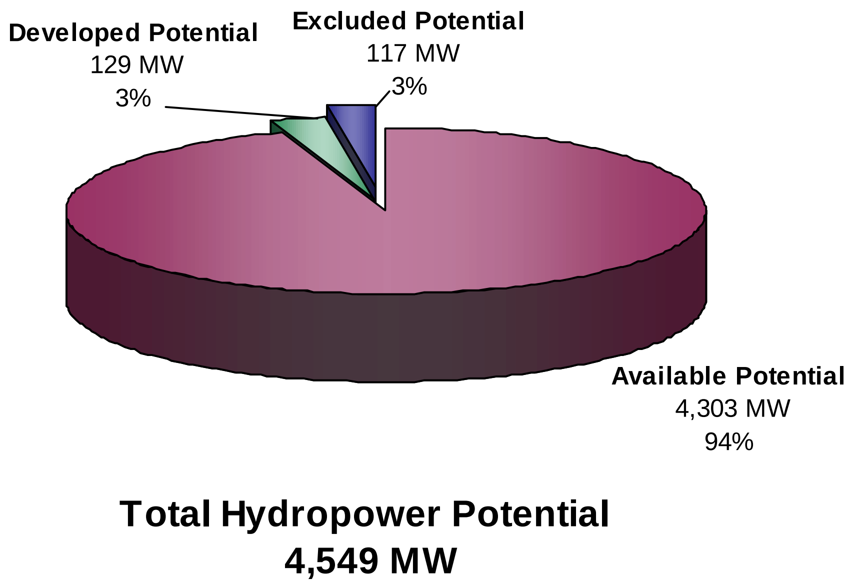


Figure B-112. Distribution of total hydropower potential in Missouri.

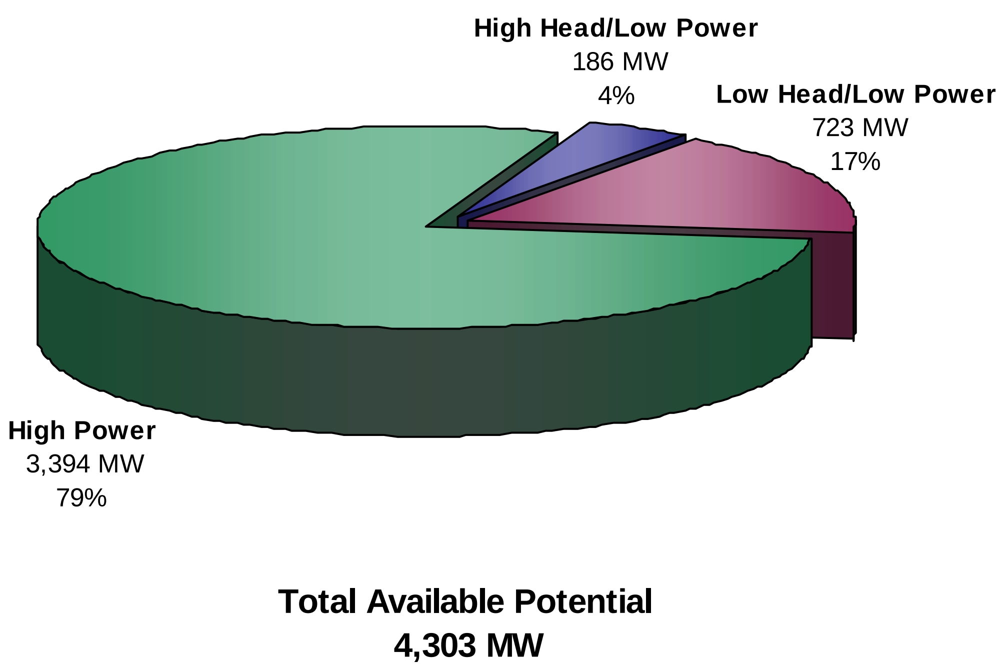


Figure B-113. Distribution of available hydropower potential in Missouri.

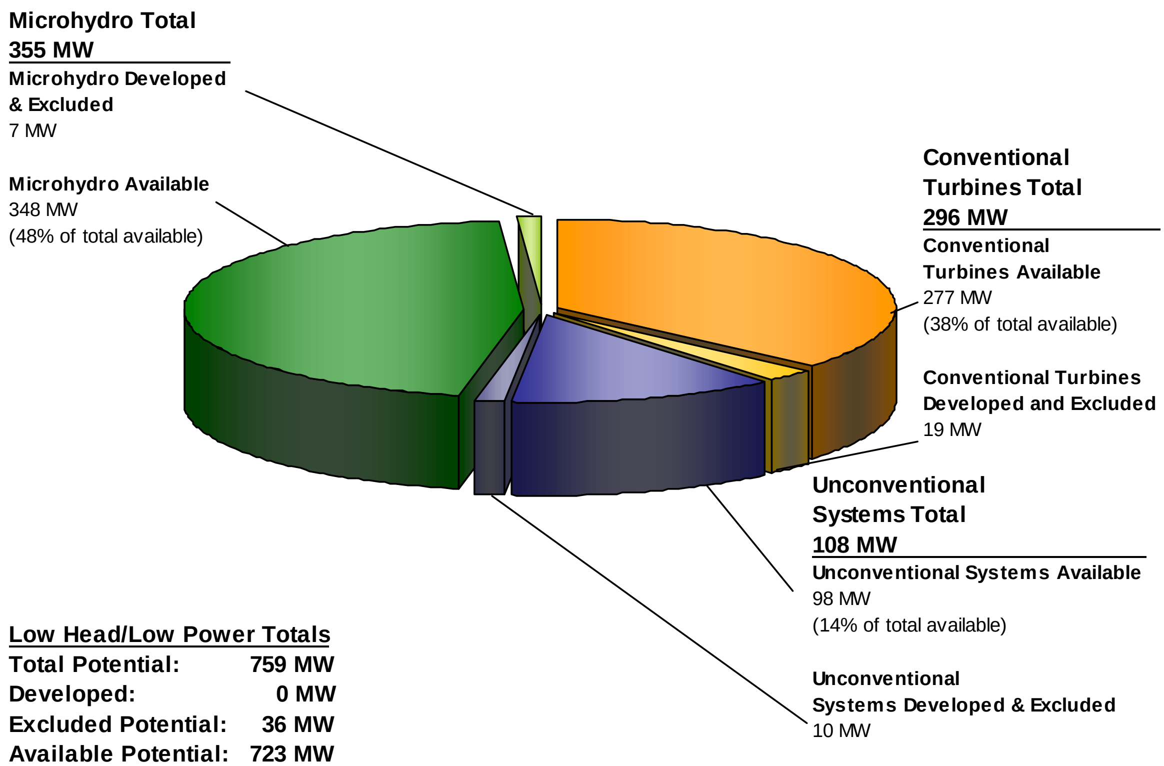


Figure B-114. Distribution of low head/low power hydropower potential in Missouri among three low head/low power hydropower technology classes.

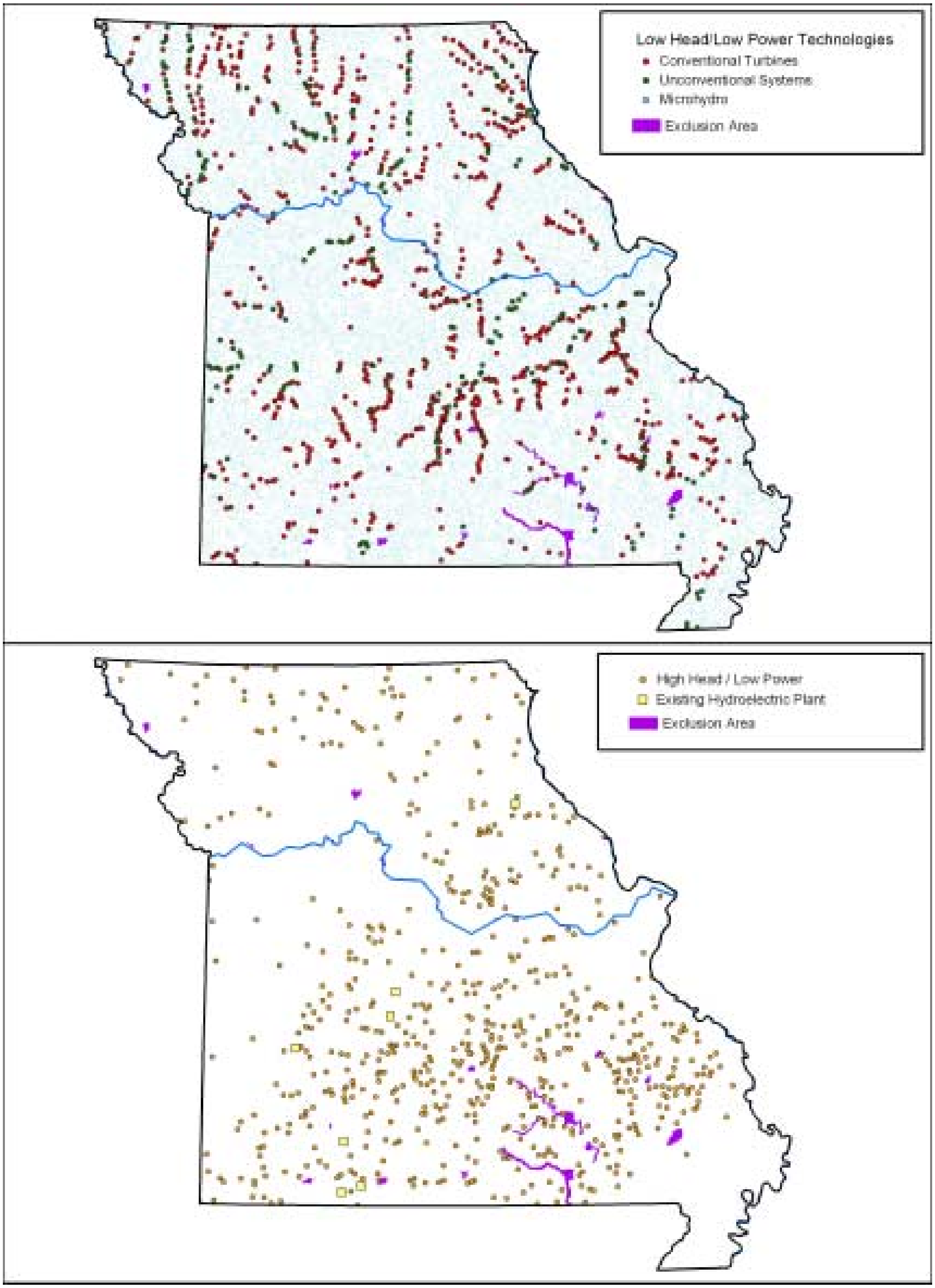


Figure B-115. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Missouri.

B.24 Montana

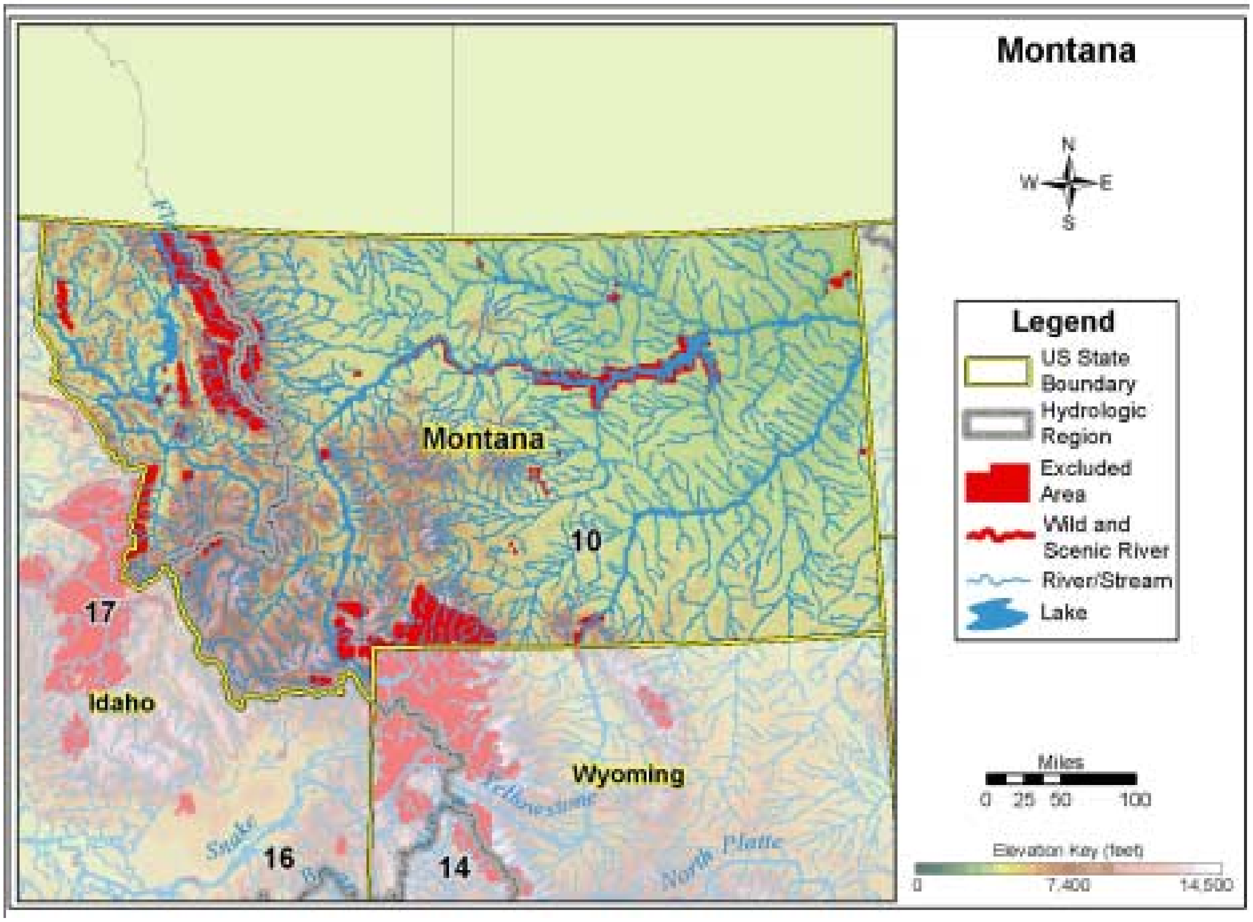


Figure B-116. Montana.

Table B-24. Summary of results of hydropower resource assessment of Montana.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**6,379**	**1,192**	**2,179**	**3,008**
TOTAL HIGH POWER	**4,602**	**1,190**	**1,899**	**1,513**
High Head/High Power	**3,721**	**1,181**	**1,762**	**778**
Low Head/High Power	**881**	**9**	**137**	**735**
TOTAL LOW POWER	**1,777**	**2**	**280**	**1,495**
High Head/Low Power	**1,140**	**2**	**239**	**899**
Low Head/Low Power	**637**	**0**	**41**	**596**
Conventional Turbine	222	0	14	208
Unconventional Systems	106	0	15	91
Microhydro	309	0	12	297

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

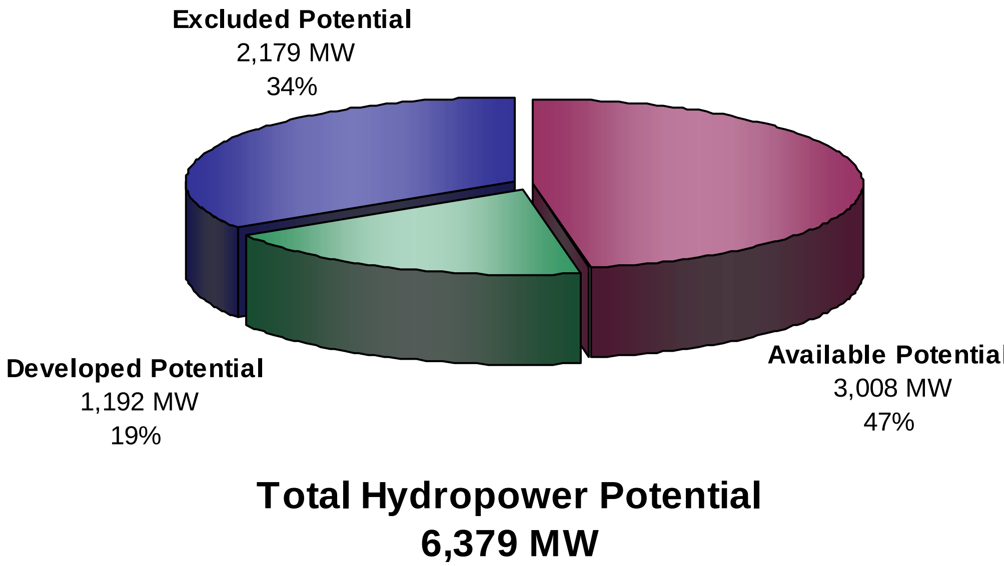


Figure B-117. Distribution of total hydropower potential in Montana.

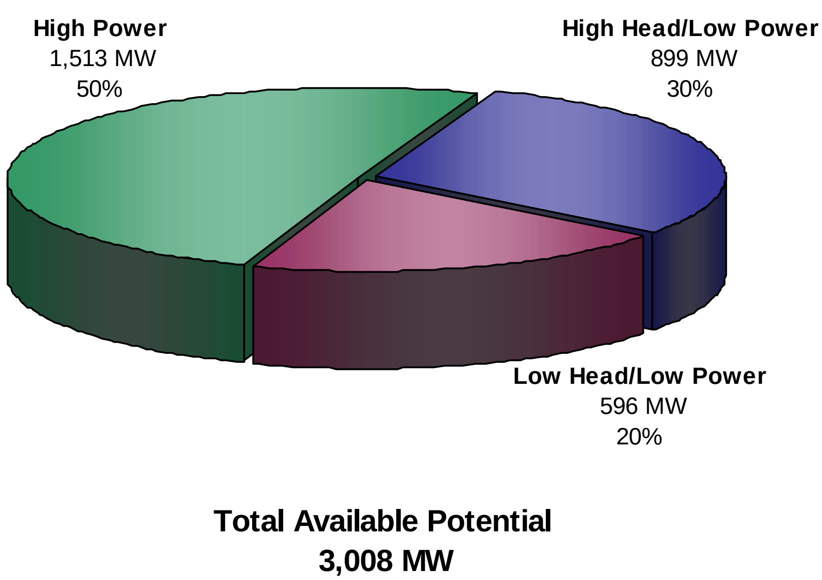


Figure B-118. Distribution of available hydropower potential in Montana.

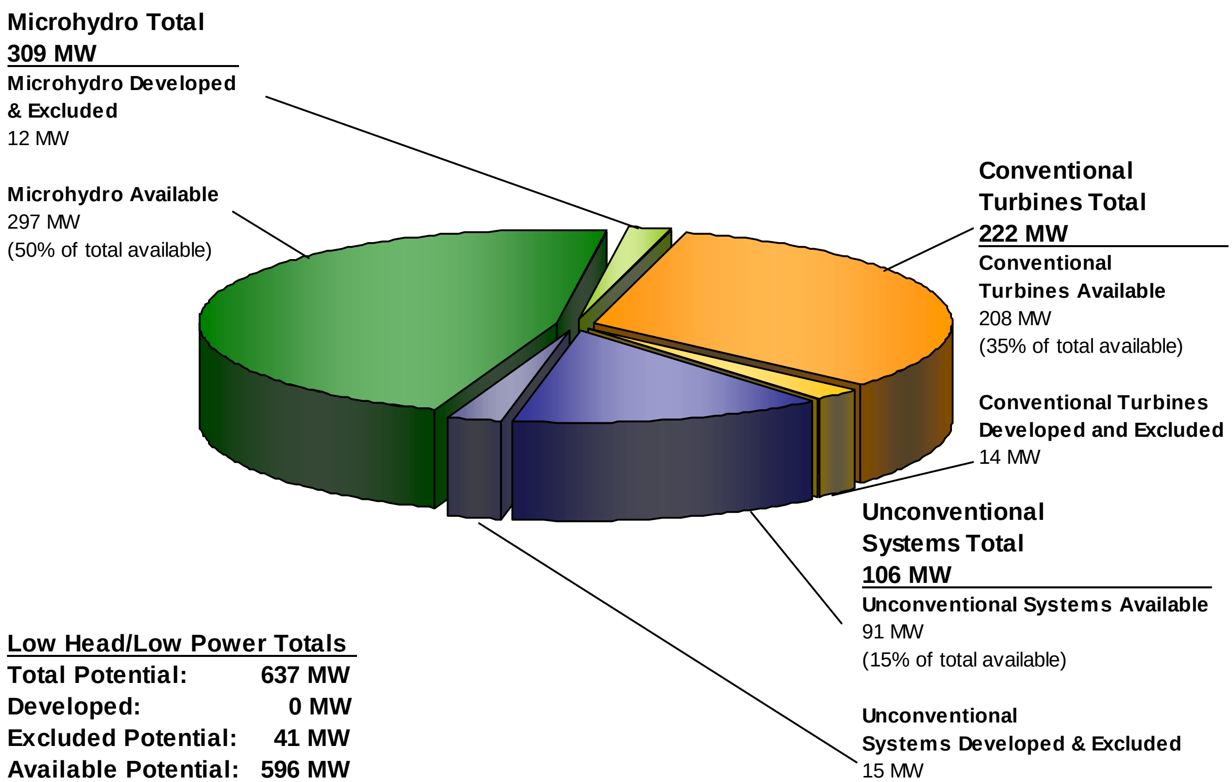


Figure B-119. Distribution of low head/low power hydropower potential in Montana among three low head/low power hydropower technology classes.

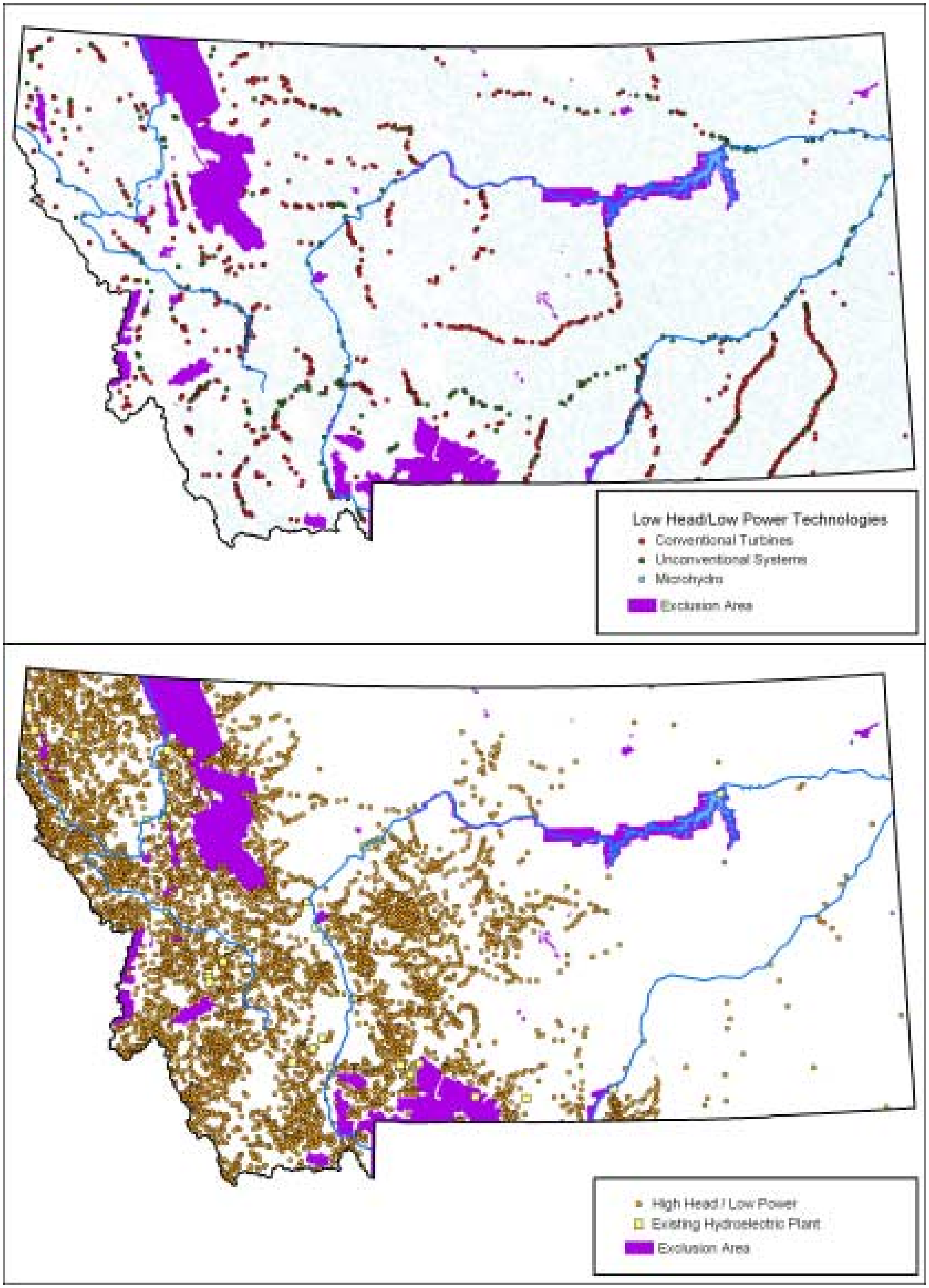


Figure B-120. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Montana.

B.25 Nebraska

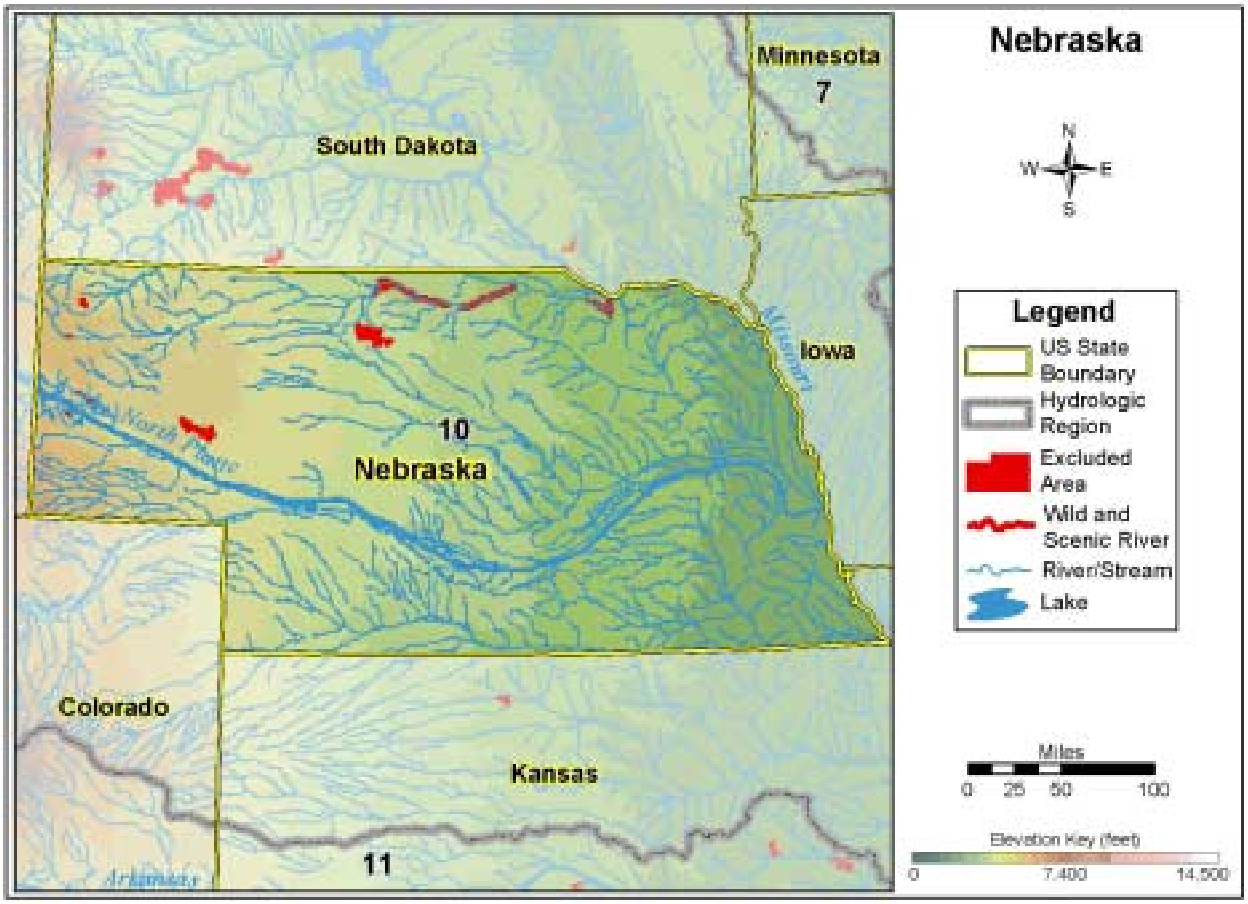


Figure B-121. Nebraska.

Table B-25. Summary of results of hydropower resource assessment of Nebraska.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,222**	**152**	**103**	**1045**
TOTAL HIGH POWER	**565**	**152**	**65**	**426**
High Head/High Power	**102**	**151**	**29**	**—**
Low Head/High Power	**463**	**1**	**36**	**426**
TOTAL LOW POWER	**657**	**0**	**38**	**619**
High Head/Low Power	**71**	**0**	**2**	**69**
Low Head/Low Power	**586**	**0**	**36**	**550**
Conventional Turbine	306	0	26	280
Unconventional Systems	78	0	7	71
Microhydro	202	0	3	199

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

Note: Available high head/high power potential was negative possibly due to overestimation of developed potential. The available high head/high power value is considered unreasonable and is not included in the power class rollup. The total power and total high power available values are rolled up values that do not match the value obtained by horizontal summing of power category values.

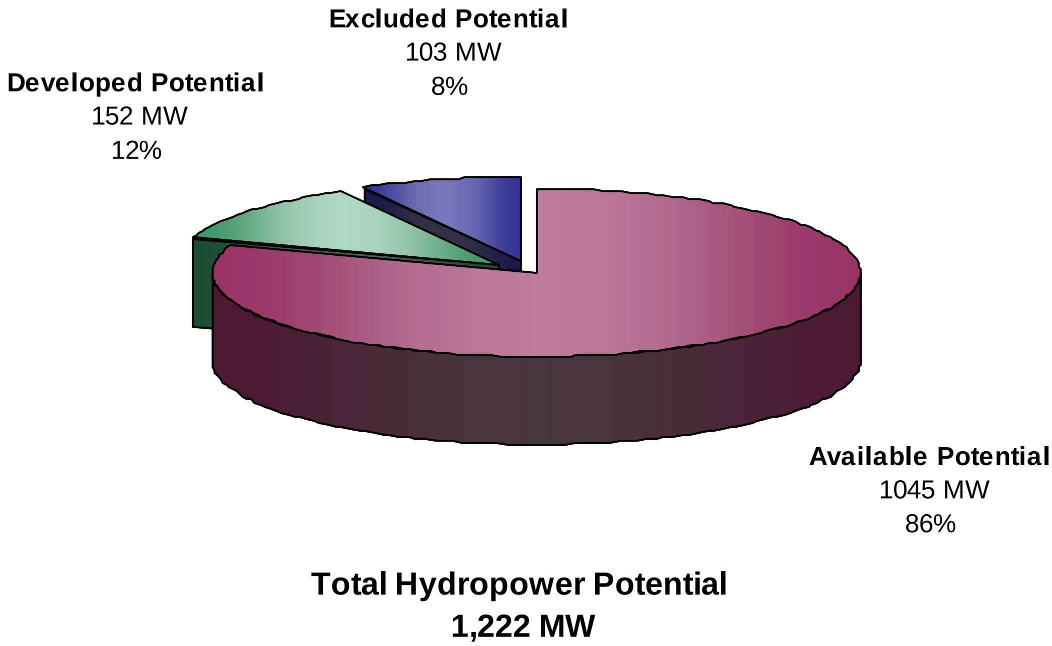


Figure B-122. Distribution of total hydropower potential in Nebraska.

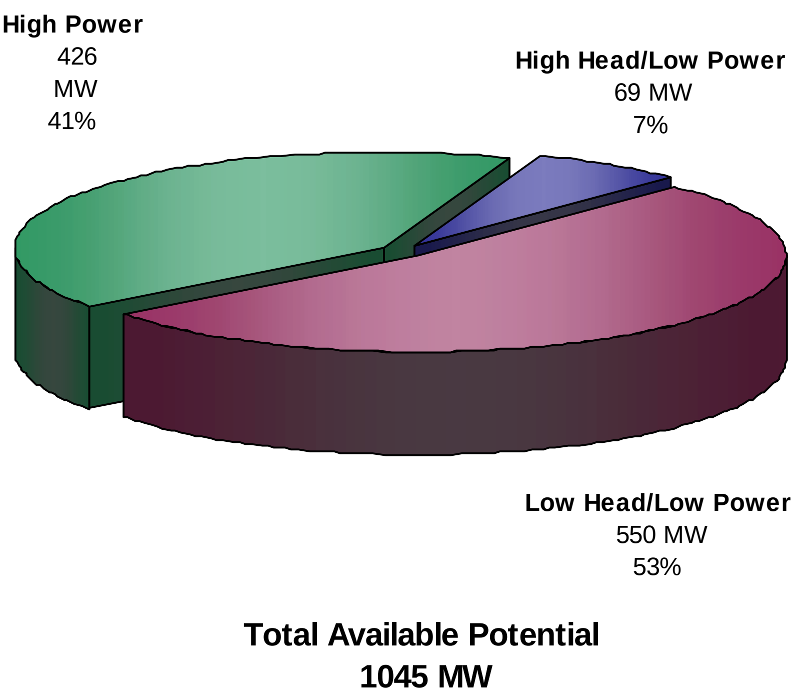


Figure B-123. Distribution of available hydropower potential in Nebraska.

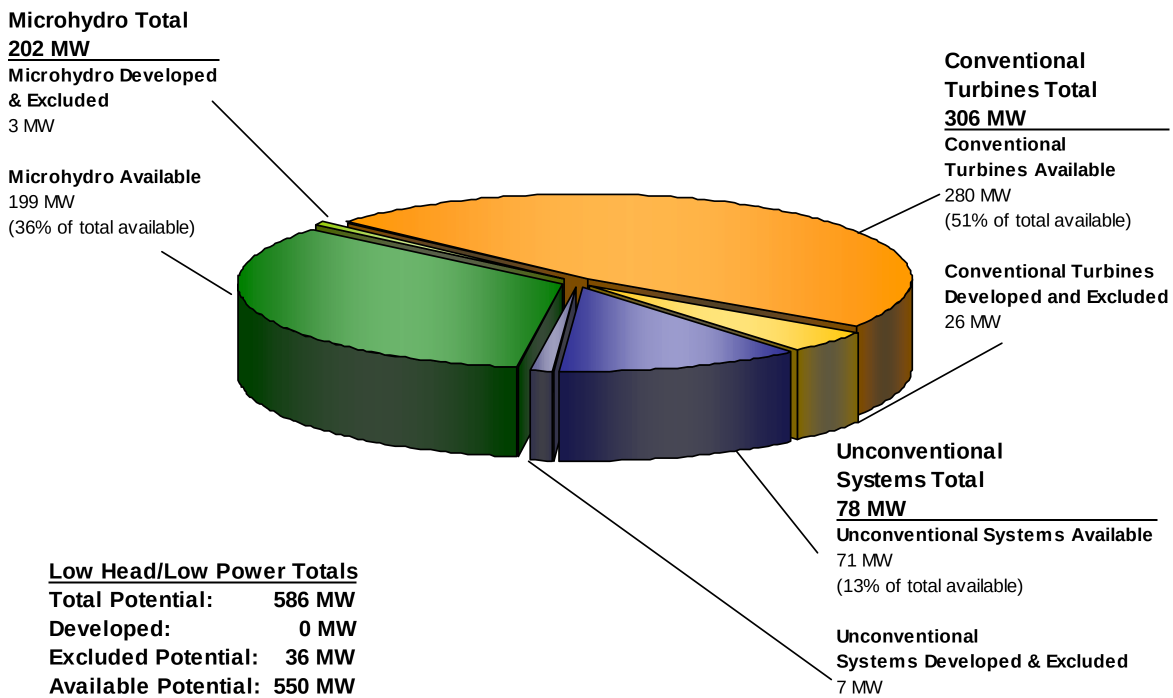


Figure B-124. Distribution of low head/low power hydropower potential in Nebraska among three low head/low power hydropower technology classes.

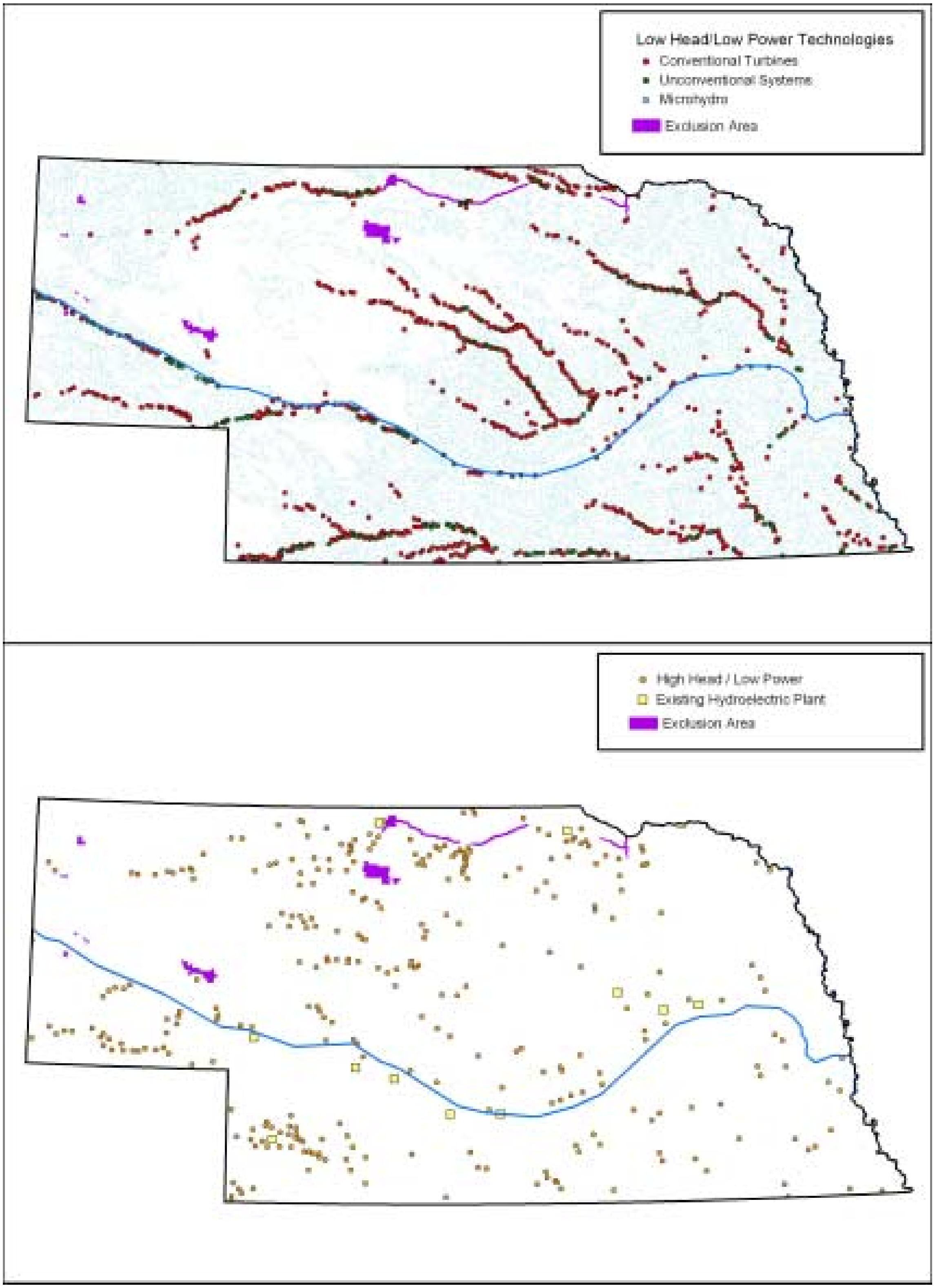


Figure B-125. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Nebraska.

B.26 Nevada

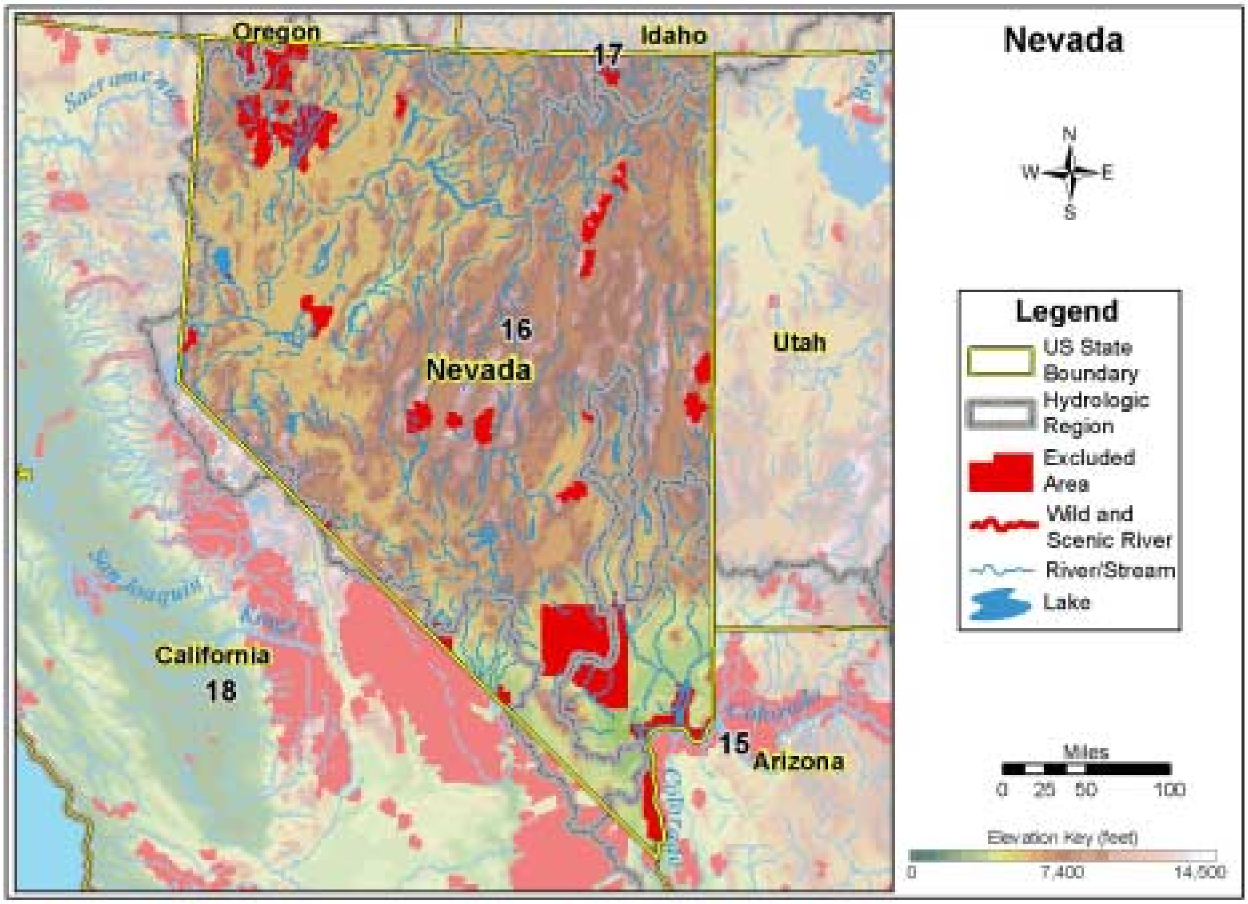


Figure B-126. Nevada.

Table B-26. Summary of results of hydropower resource assessment of Nevada.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,137**	**263**	**147**	**789**
TOTAL HIGH POWER	**206**	**262**	**0**	**6**
High Head/High Power	**200**	**262**	**—**	**—**
Low Head/High Power	**6**	**0**	**0**	**6**
TOTAL LOW POWER	**931**	**1**	**147**	**783**
High Head/Low Power	**473**	**0**	**102**	**371**
Low Head/Low Power	**458**	**1**	**45**	**412**
Conventional Turbine	70	1	1	68
Unconventional Systems	9	0	1	8
Microhydro	379	0	43	336

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

Note: Excluded high head/high power potential was negative possibly due to overestimation of developed potential in excluded zones. The high head/high power excluded and available values are considered unreliable and are not included in the power class rollups. The total power and total high power available values are rolled up values that do not match the value obtained by horizontal summing of power category values.

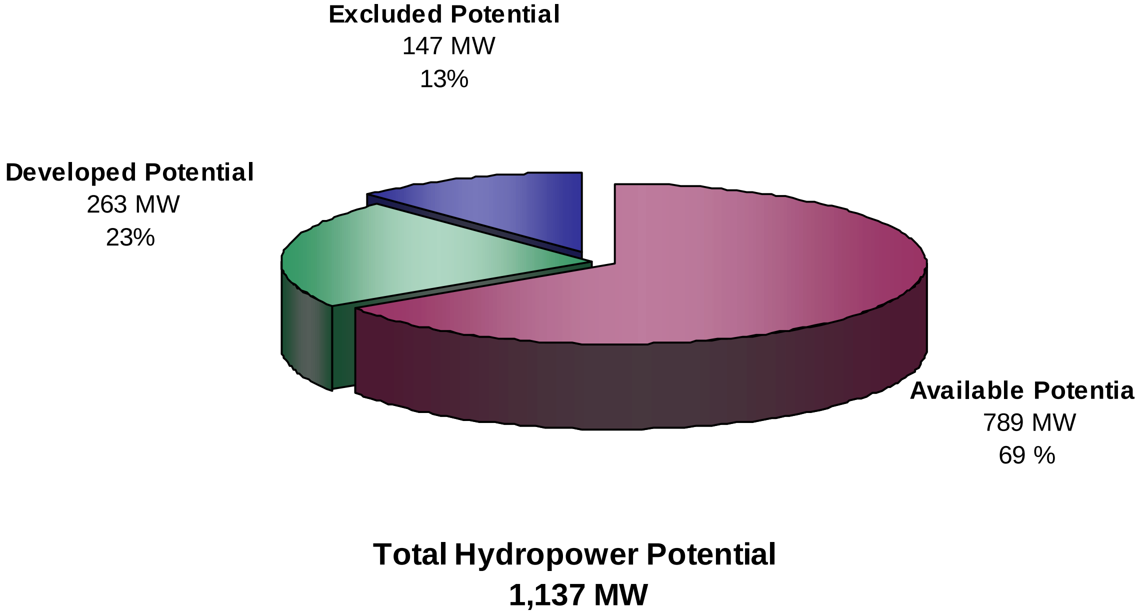


Figure B-127. Distribution of total hydropower potential in Nevada.

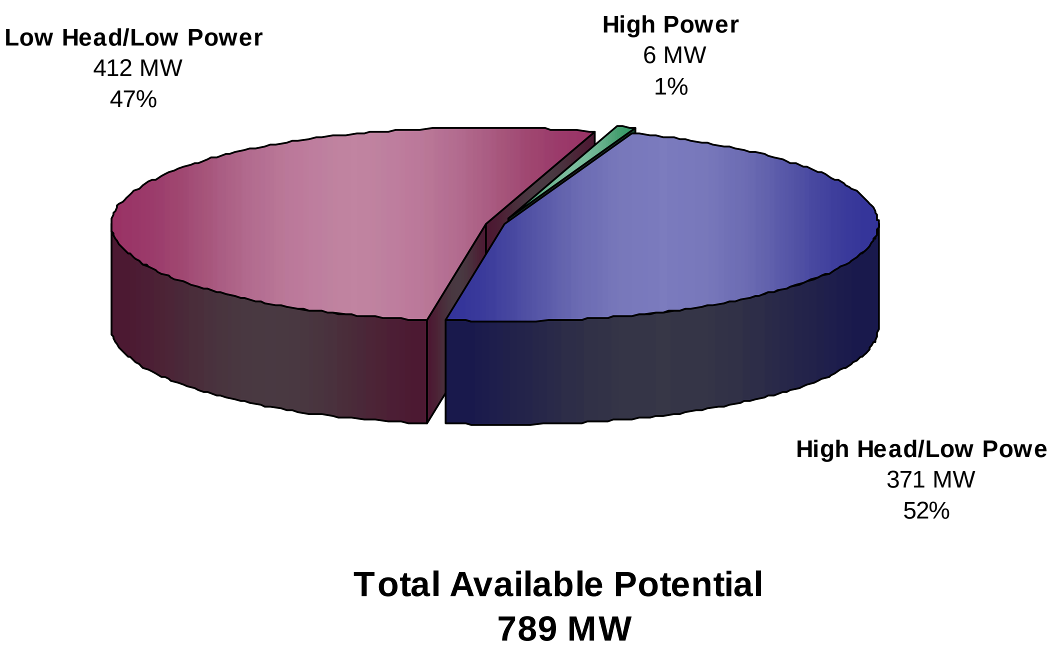


Figure B-128. Distribution of available hydropower potential in Nevada.

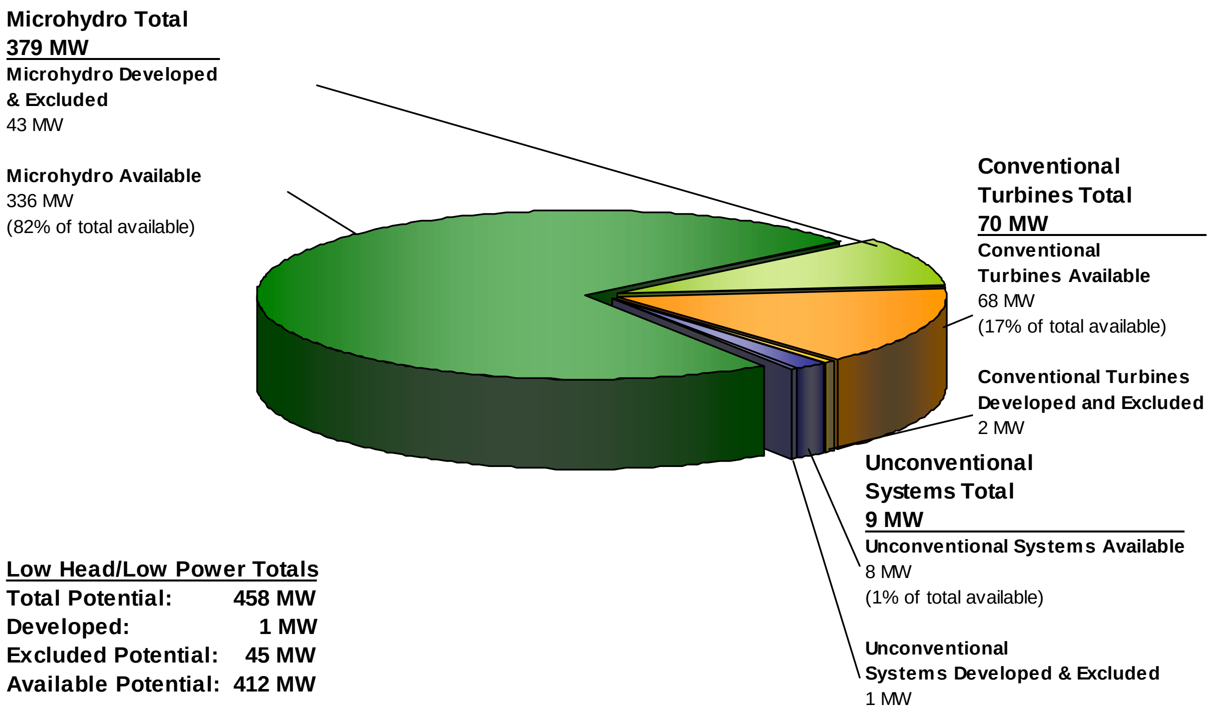


Figure B-129. Distribution of low head/low power hydropower potential in Nevada among three low head/low power hydropower technology classes.

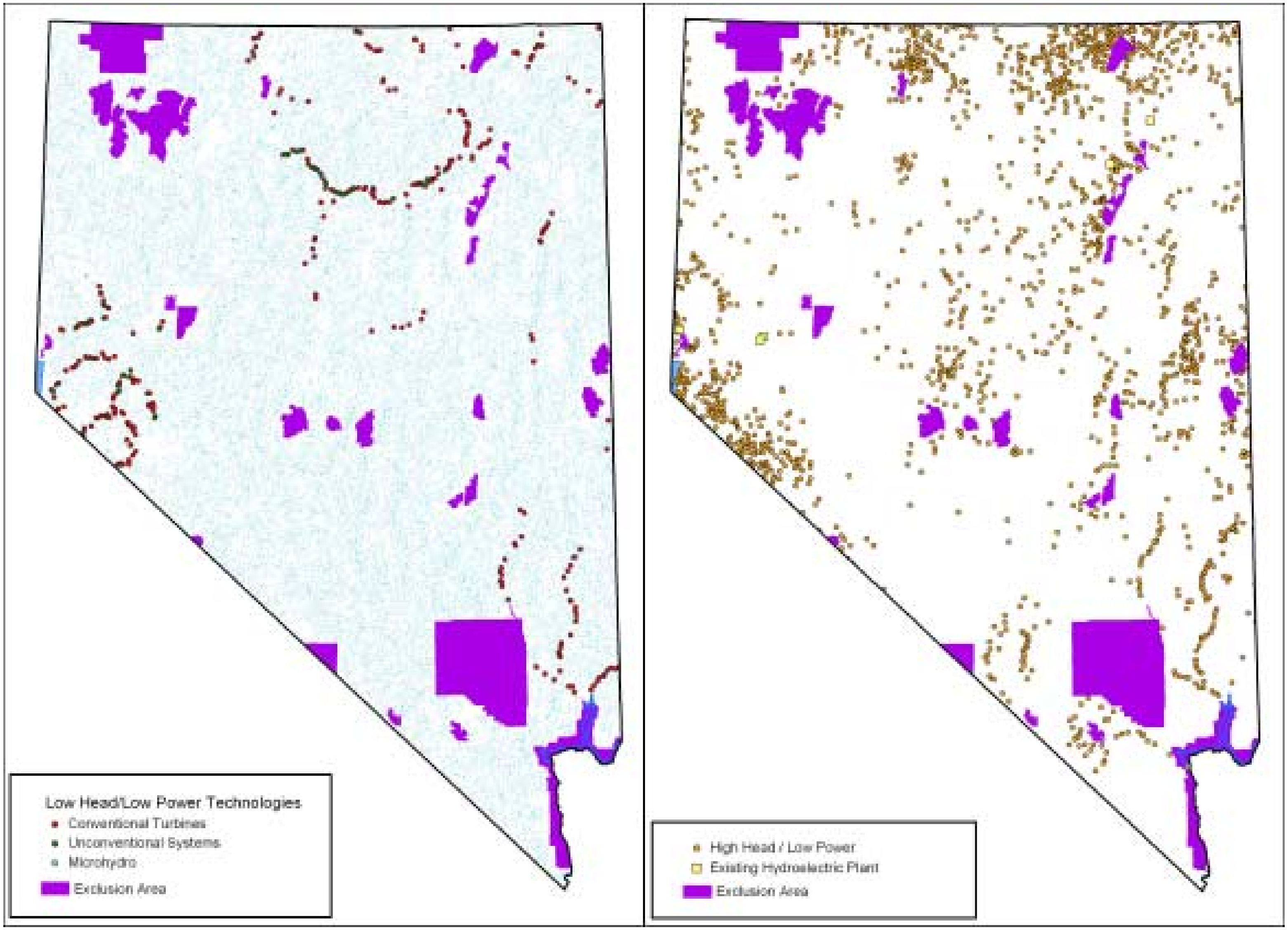


Figure B-130. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Nevada.

B.27 New Hampshire

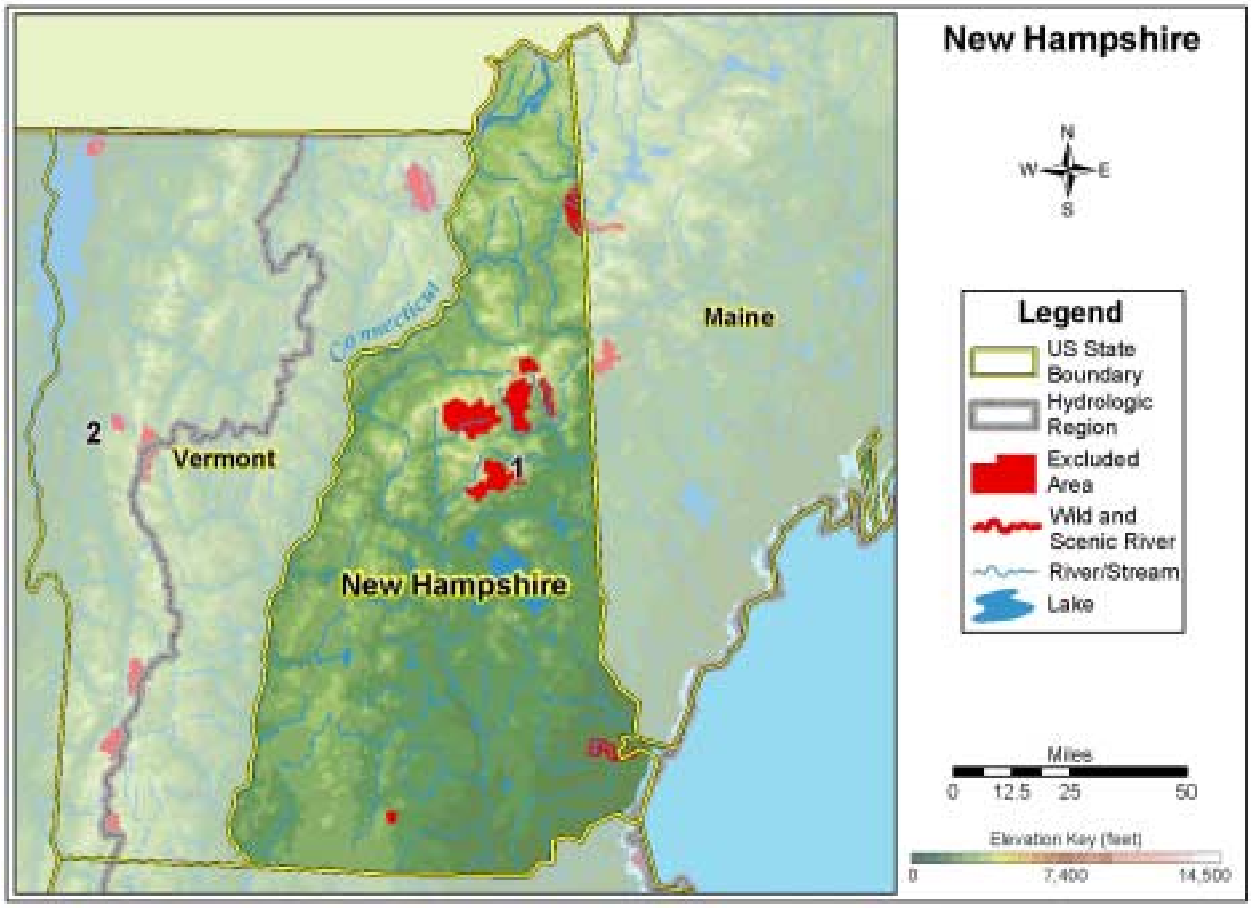


Figure B-131. New Hampshire.

Table B-27. Summary of results of hydropower resource assessment of New Hampshire.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,181**	**187**	**89**	**905**
TOTAL HIGH POWER	**804**	**177**	**59**	**568**
High Head/High Power	**650**	**156**	**52**	**442**
Low Head/High Power	**154**	**21**	**7**	**126**
TOTAL LOW POWER	**377**	**10**	**30**	**337**
High Head/Low Power	**277**	**3**	**28**	**246**
Low Head/Low Power	**100**	**7**	**2**	**91**
Conventional Turbine	44	7	1	36
Unconventional Systems	16	0	0	16
Microhydro	40	0	1	39

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

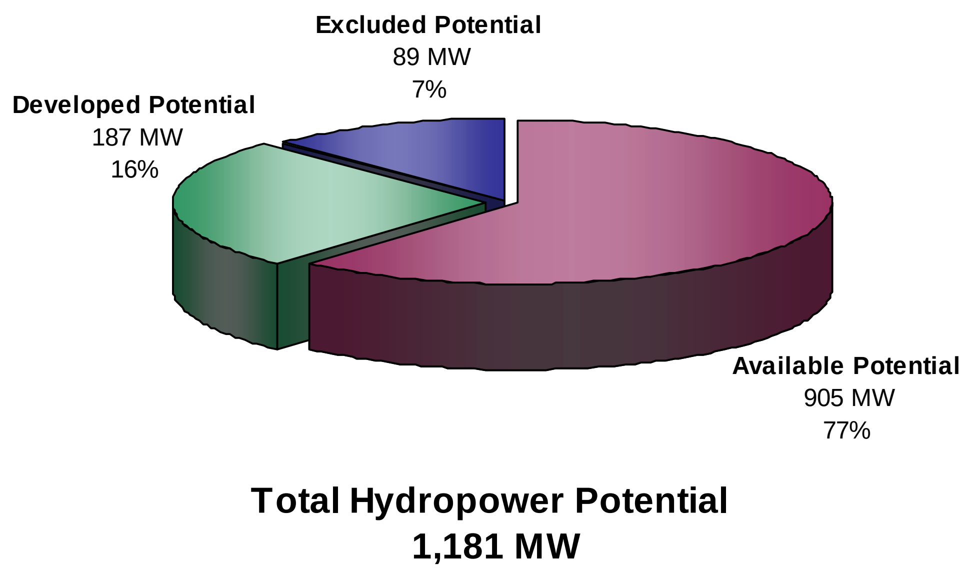


Figure B-132. Distribution of total hydropower potential in New Hampshire.

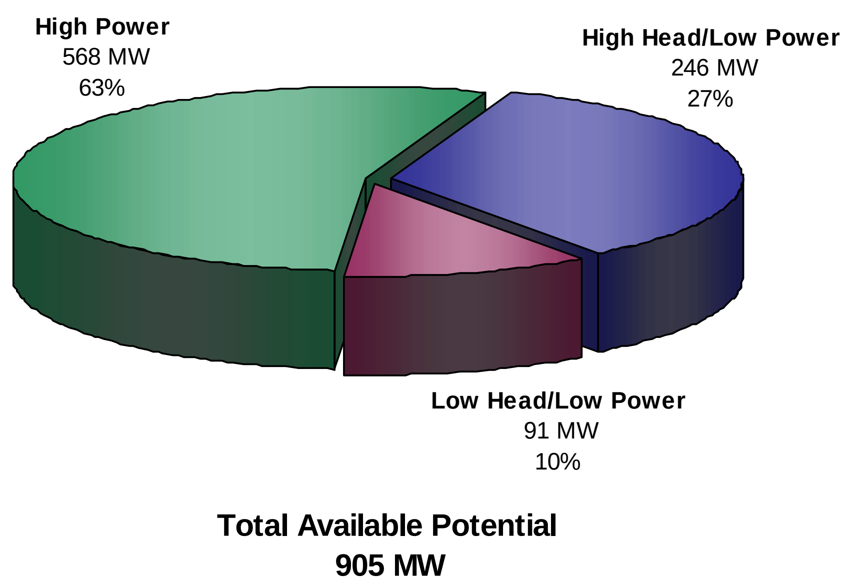


Figure B-133. Distribution of available hydropower potential in New Hampshire.

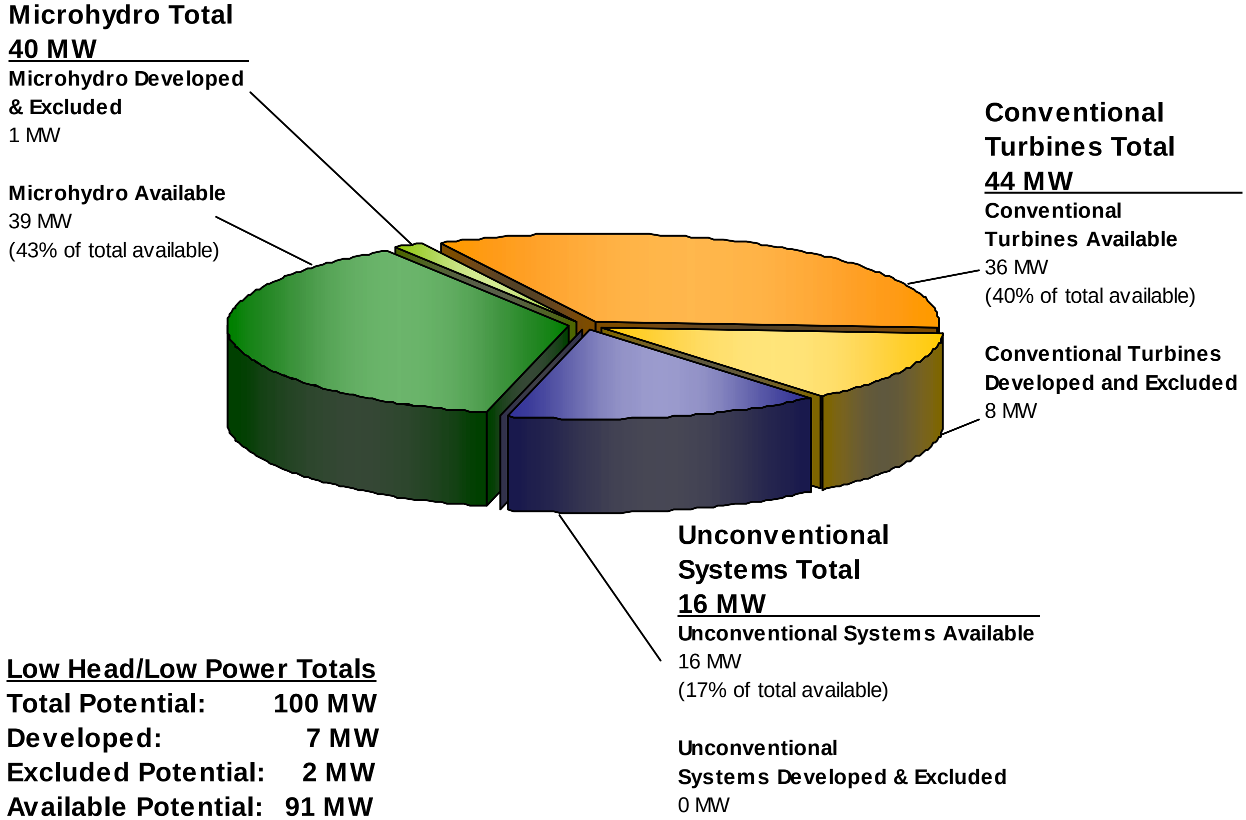


Figure B-134. Distribution of low head/low power hydropower potential in New Hampshire among three low head/low power hydropower technology classes.

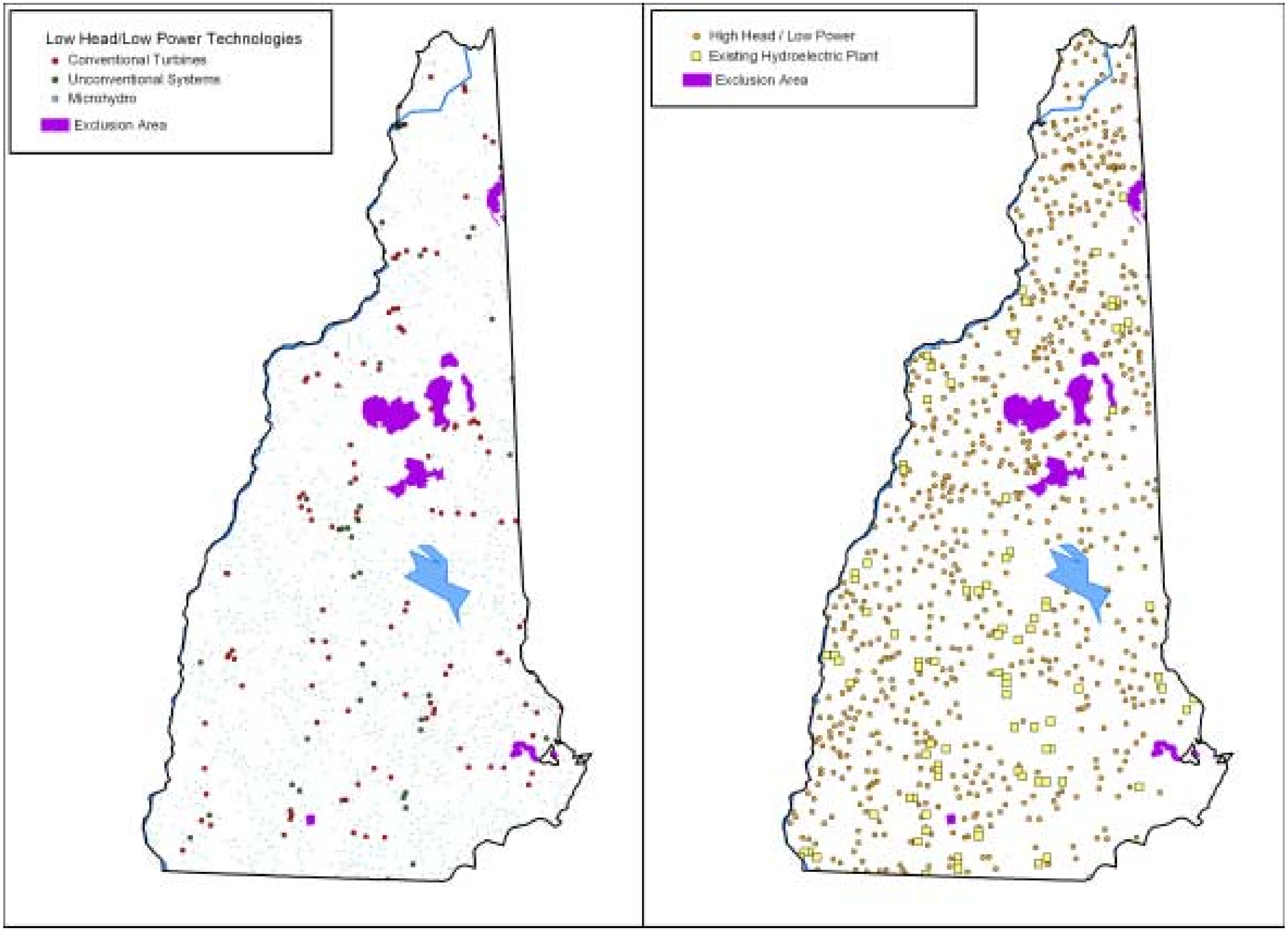


Figure B-130. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in New Hampshire.

B.28 New Jersey

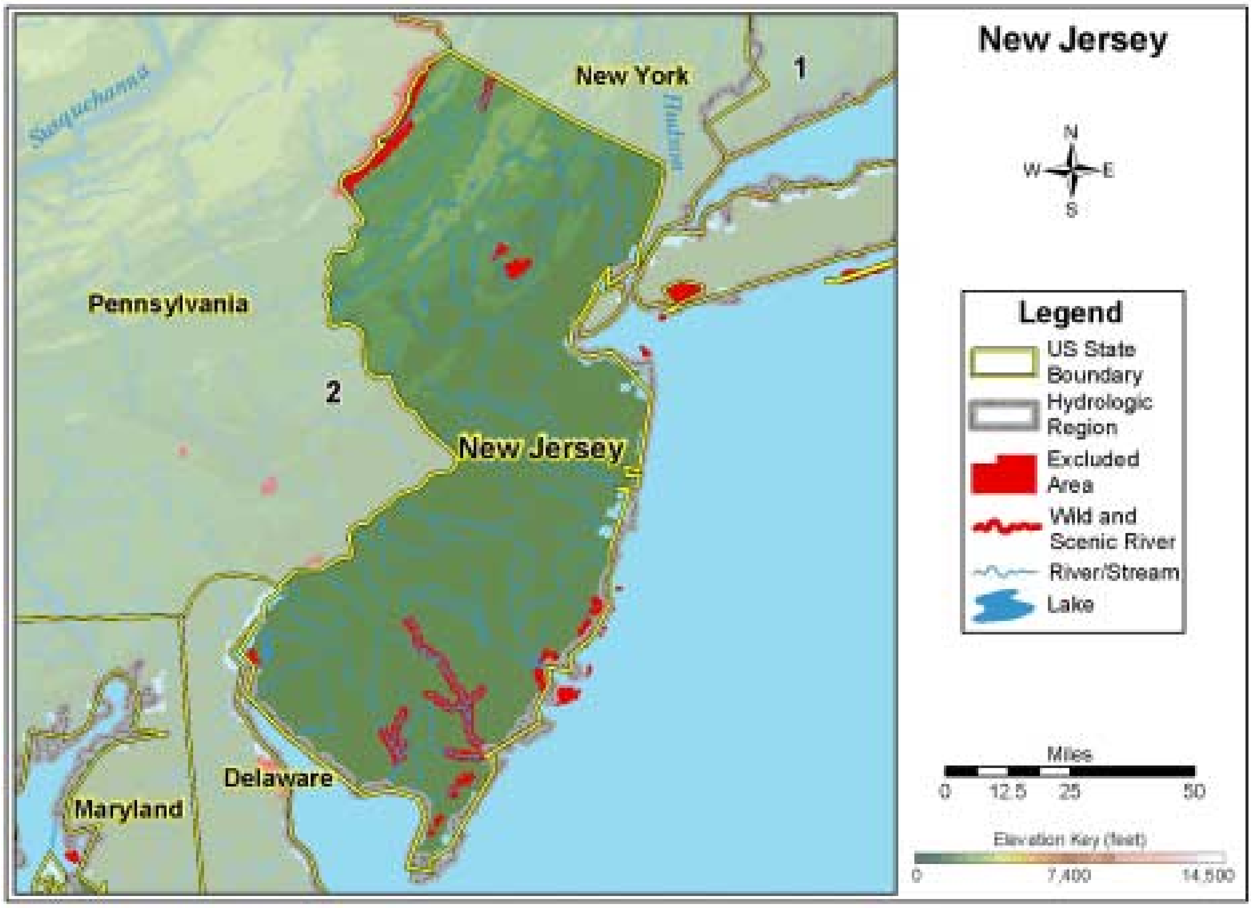


Figure B-136. New Jersey.

Table B-28. Summary of results of hydropower resource assessment of New Jersey.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**300**	**6**	**37**	**257**
TOTAL HIGH POWER	**203**	**6**	**30**	**167**
High Head/High Power	**76**	**5**	**0**	**71**
Low Head/High Power	**127**	**1**	**30**	**96**
TOTAL LOW POWER	**97**	**0**	**7**	**90**
High Head/Low Power	**42**	**0**	**4**	**38**
Low Head/Low Power	**55**	**0**	**3**	**52**
Conventional Turbine	21	0	1	20
Unconventional Systems	5	0	0	5
Microhydro	29	0	2	27

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

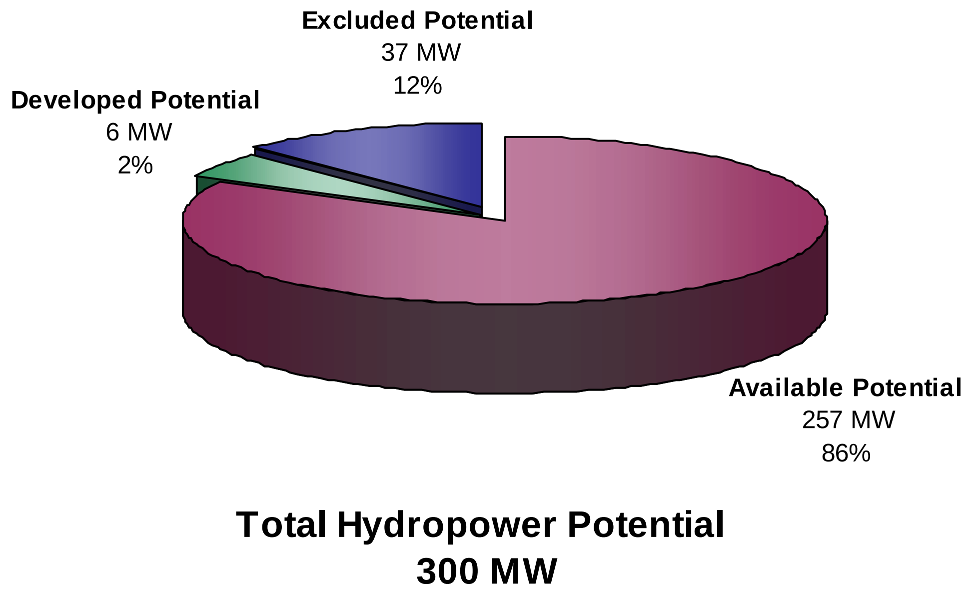


Figure B-137. Distribution of total hydropower potential in New Jersey.

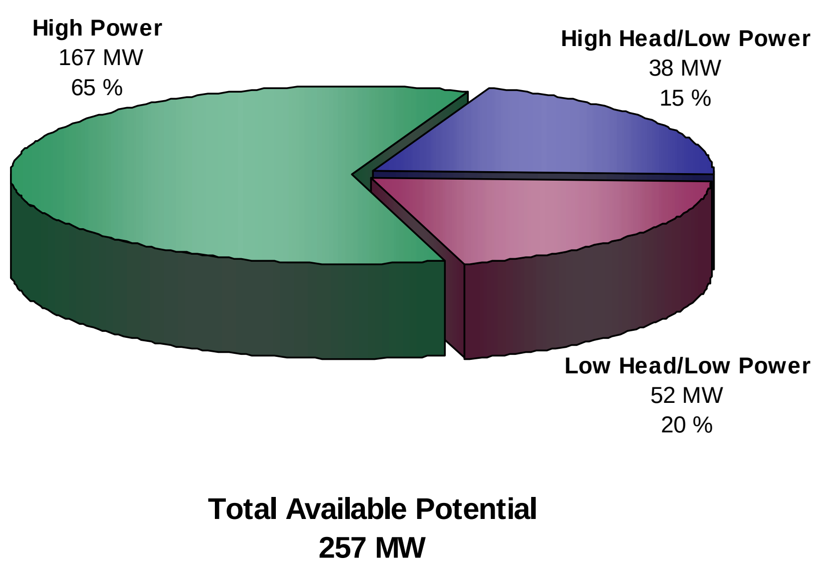


Figure B-138. Distribution of available hydropower potential in New Jersey.

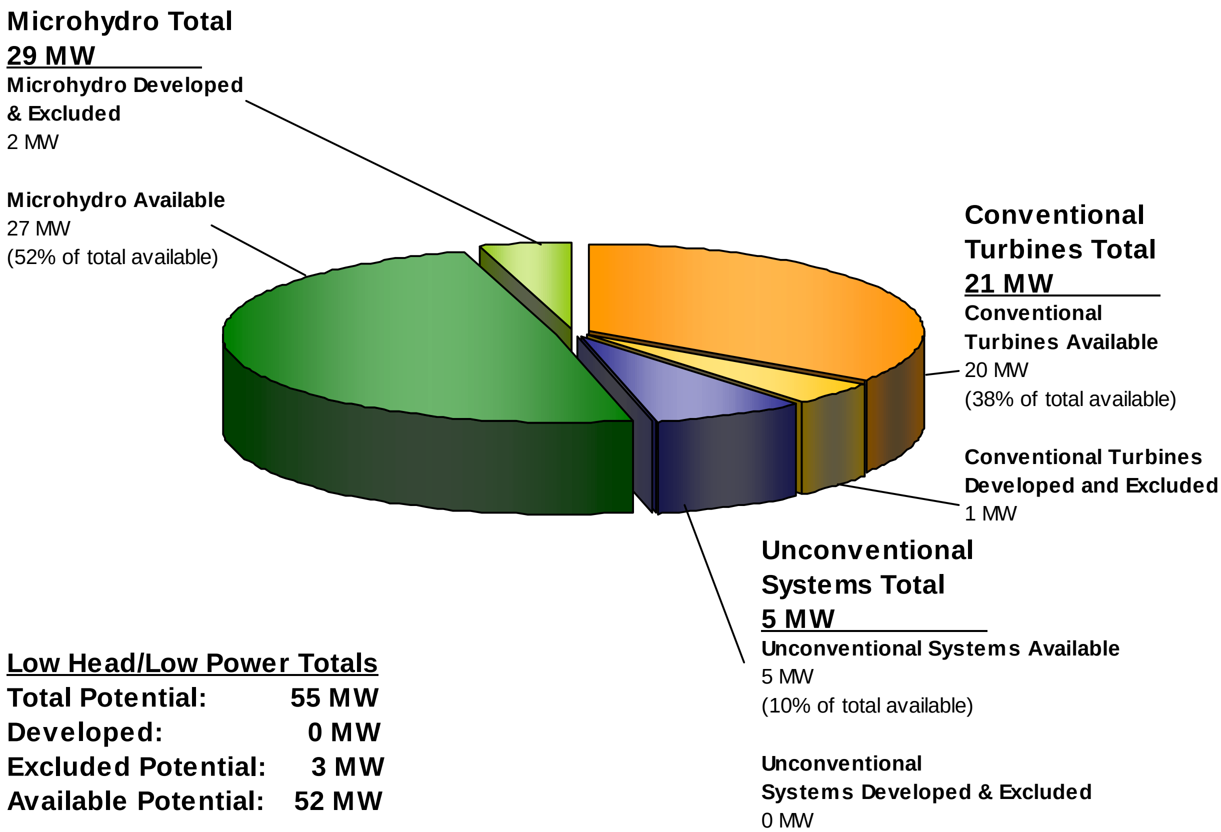


Figure B-139. Distribution of low head/low power hydropower potential in New Jersey among three low head/low power hydropower technology classes.

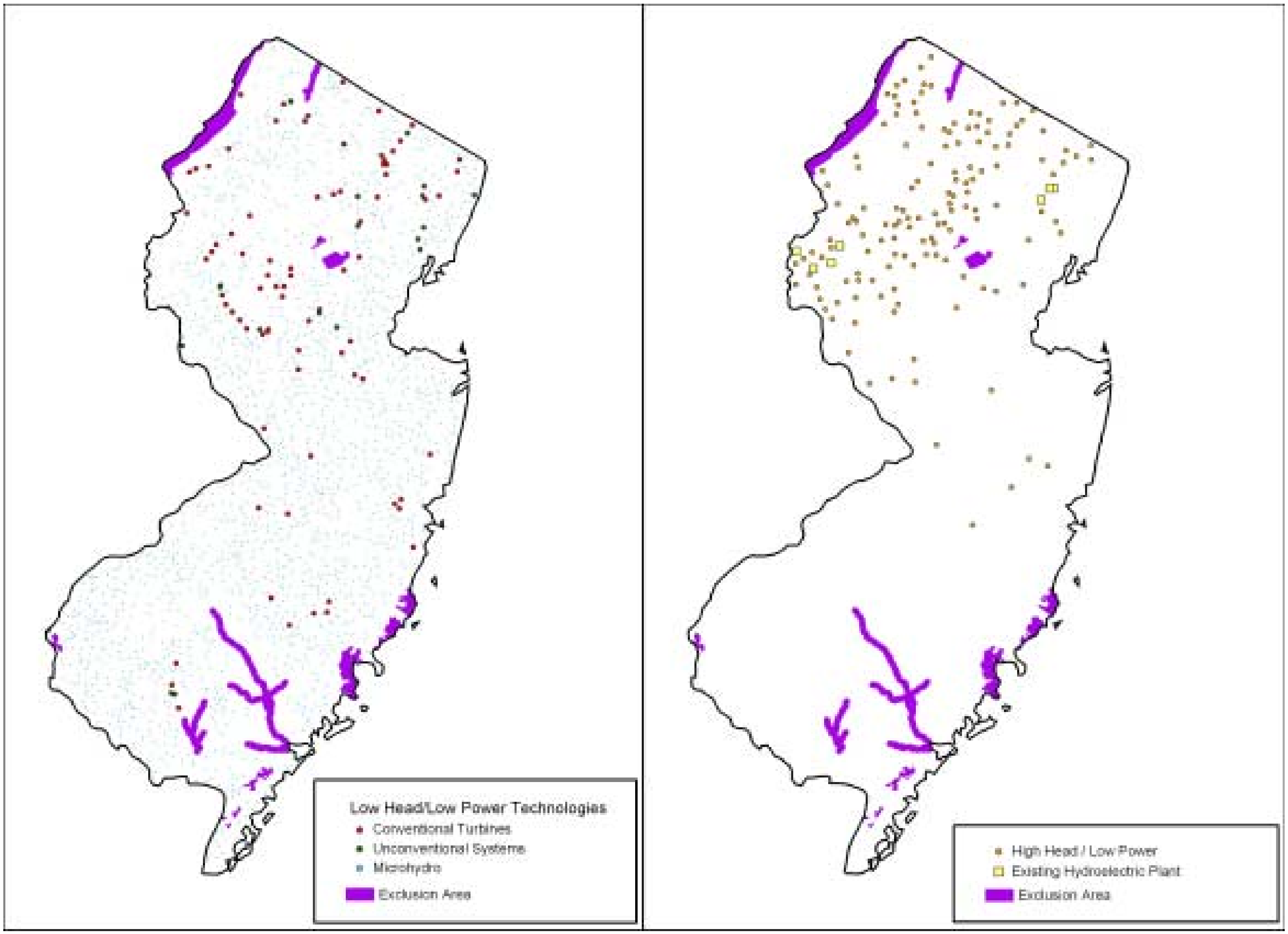


Figure B-140. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in New Jersey.

B.29 New Mexico

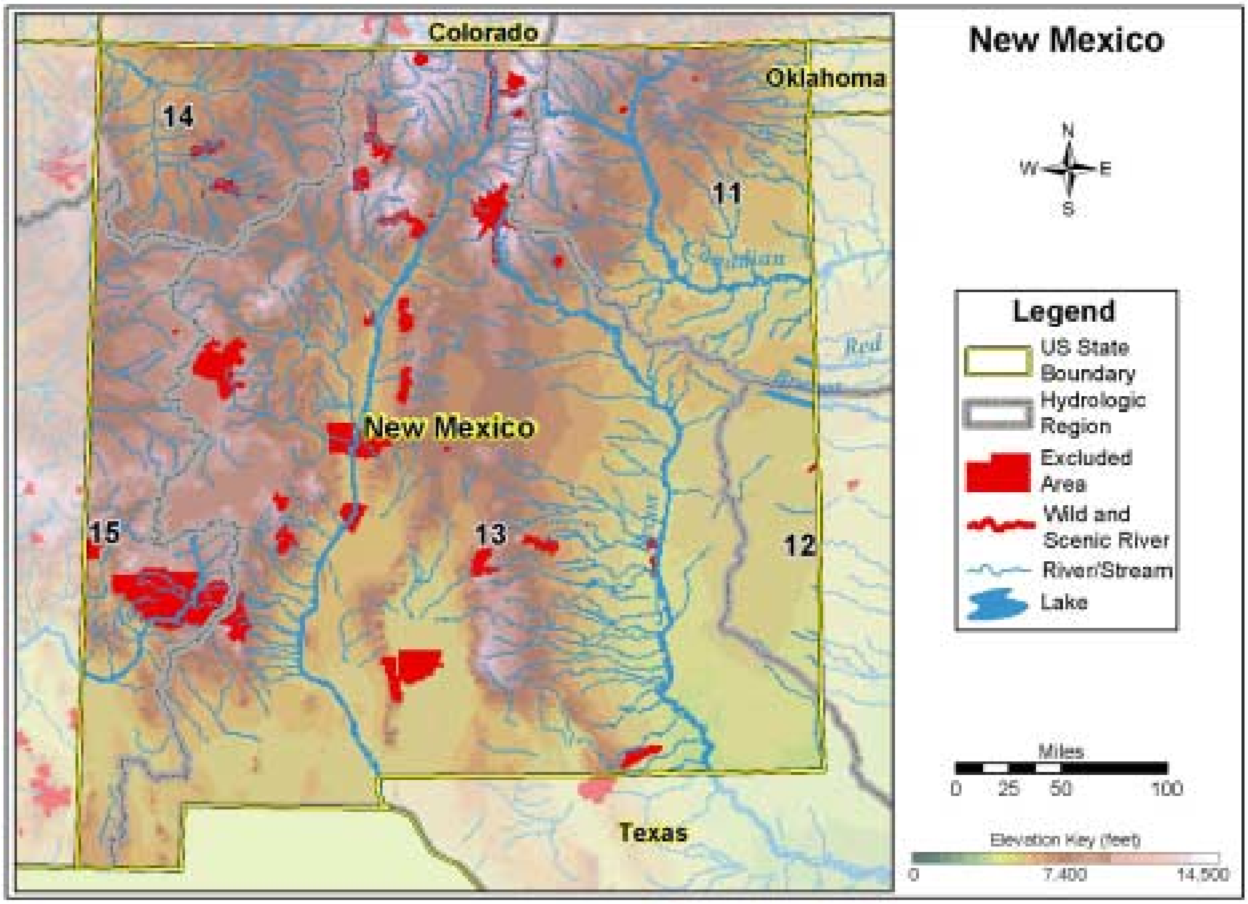


Figure B-141. New Mexico.

Table B-29. Summary of results of hydropower resource assessment of New Mexico.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,729**	**30**	**368**	**1,331**
TOTAL HIGH POWER	**595**	**30**	**182**	**383**
High Head/High Power	**488**	**30**	**177**	**281**
Low Head/High Power	**107**	**0**	**5**	**102**
TOTAL LOW POWER	**1,134**	**0**	**186**	**948**
High Head/Low Power	**630**	**0**	**140**	**490**
Low Head/Low Power	**504**	**0**	**46**	**458**
Conventional Turbine	124	0	14	110
Unconventional Systems	40	0	4	36
Microhydro	340	0	28	312

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

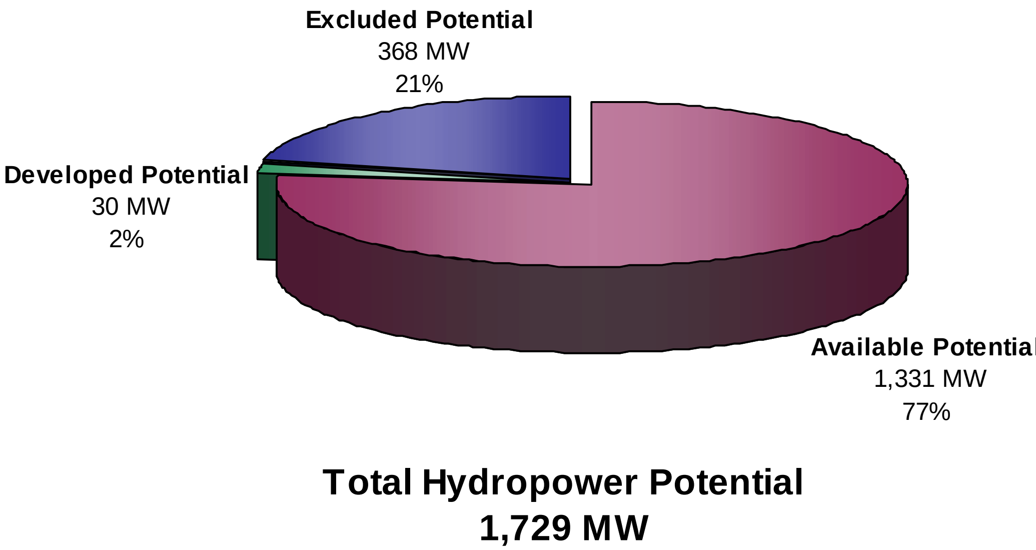


Figure B-142. Distribution of total hydropower potential in New Mexico.

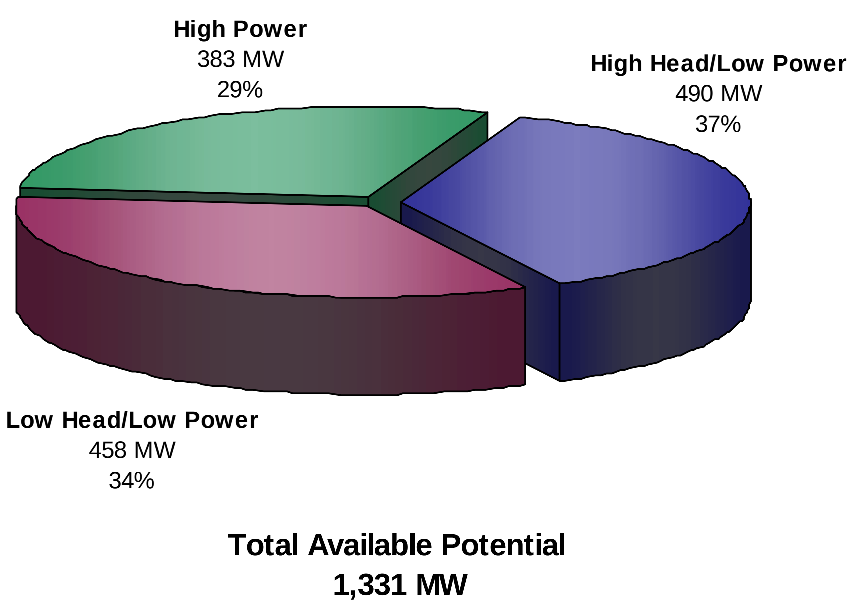


Figure B-143. Distribution of available hydropower potential in New Mexico.

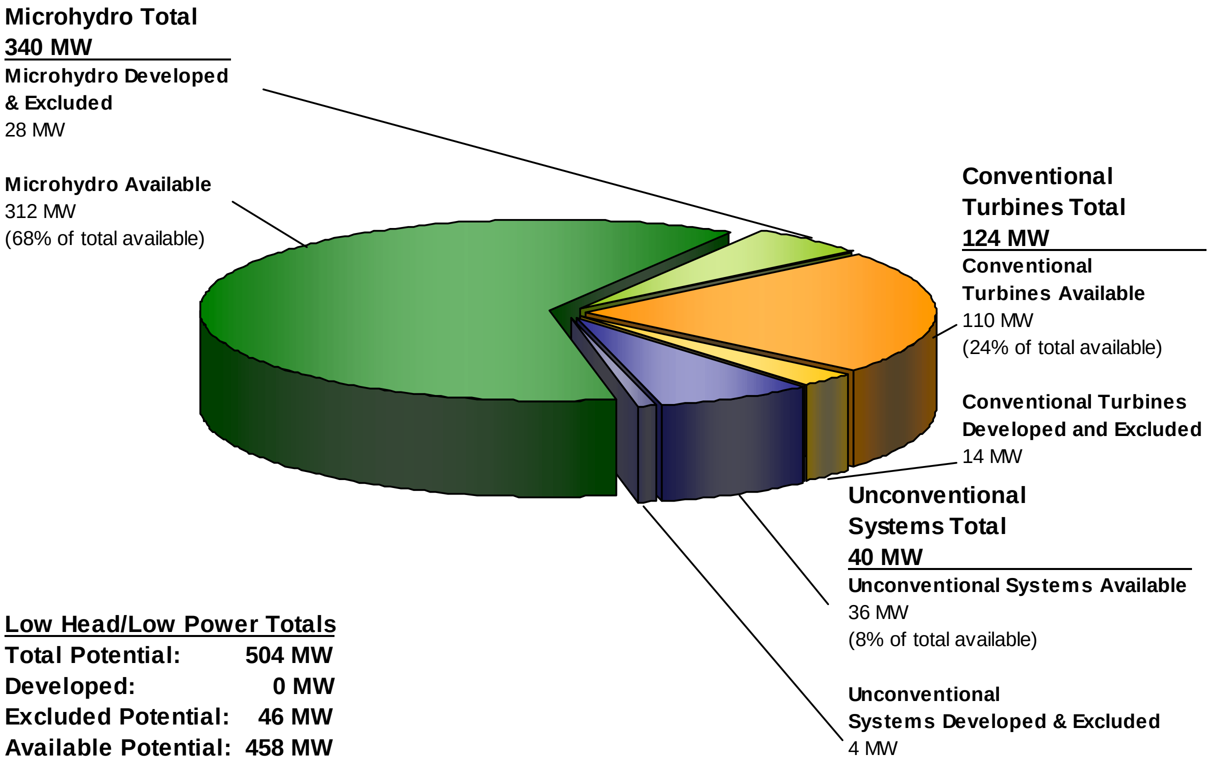


Figure B-144. Distribution of low head/low power hydropower potential in New Mexico among three low head/low power hydropower technology classes.

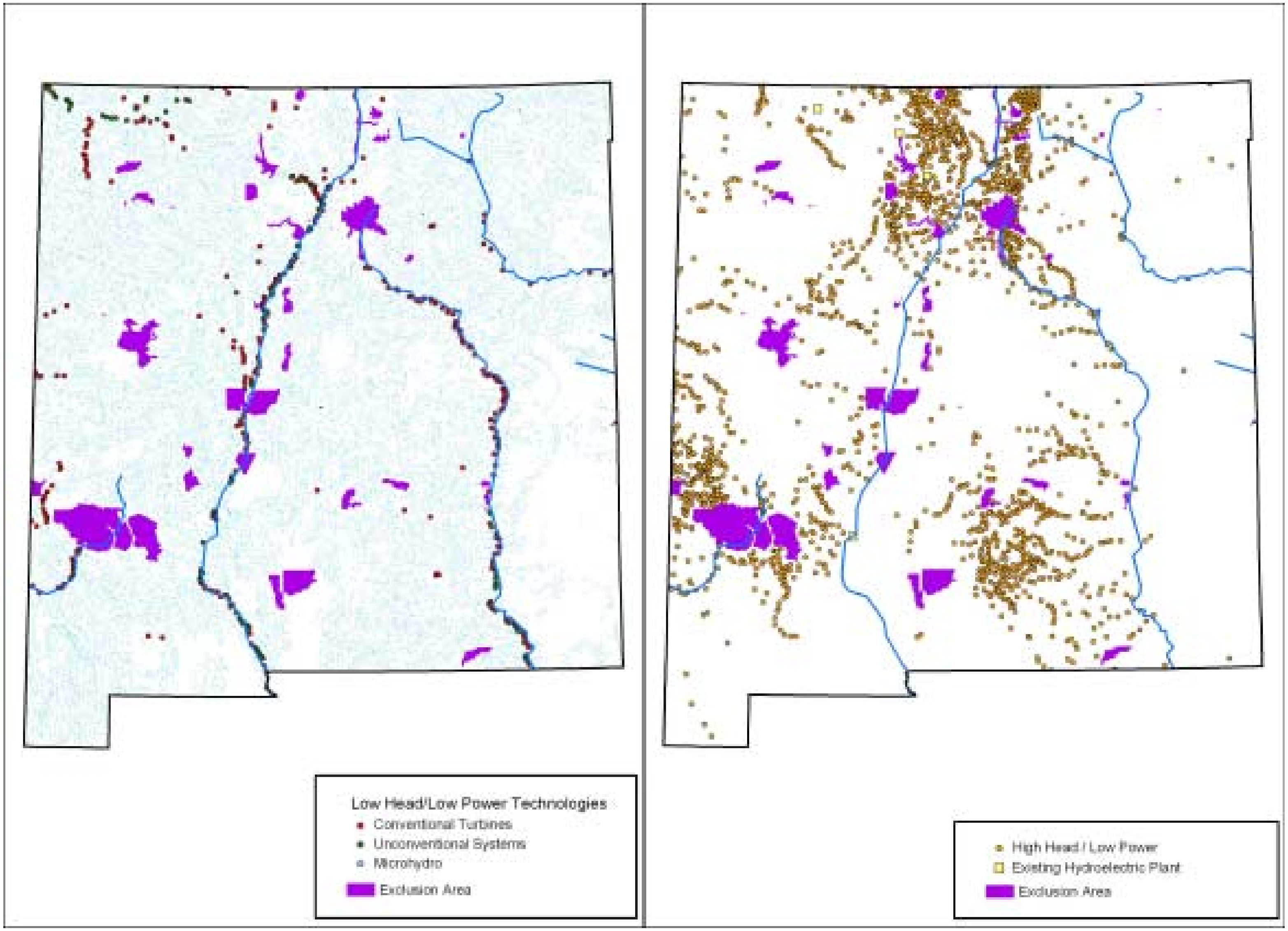


Figure B-145. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in New Mexico.

B.30 New York

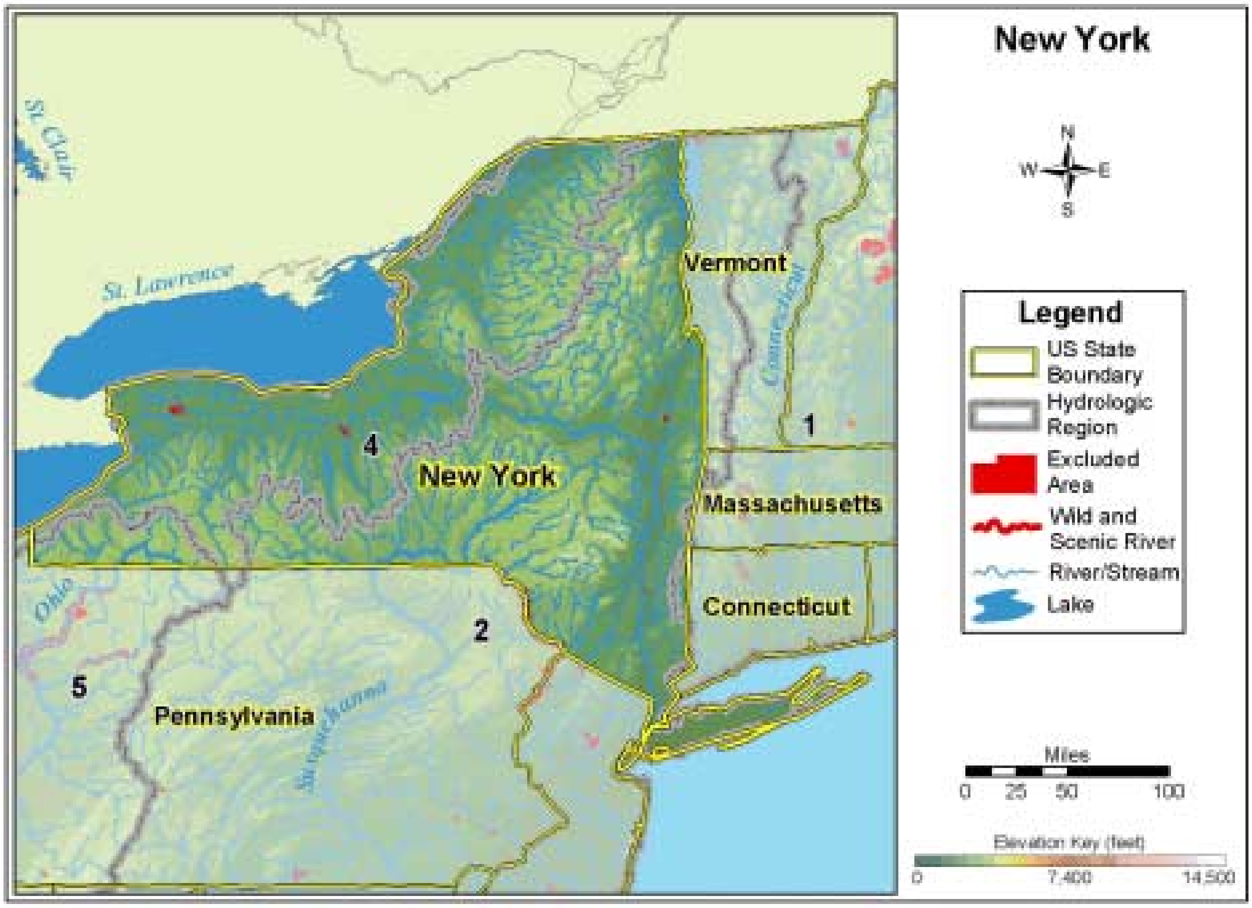


Figure B-146. New York.

Table B-30. Summary of results of hydropower resource assessment of New York.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**4,902**	**2,862**	**110**	**1,930**
TOTAL HIGH POWER	**3,345**	**2,846**	**99**	**400**
High Head/High Power	**2,790**	**2,727**	**35**	**28**
Low Head/High Power	**555**	**119**	**64**	**372**
TOTAL LOW POWER	**1,557**	**16**	**11**	**1,530**
High Head/Low Power	**1,063**	**5**	**7**	**1,051**
Low Head/Low Power	**494**	**11**	**4**	**479**
Conventional Turbine	194	11	0	183
Unconventional Systems	72	0	3	69
Microhydro	228	0	1	227

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

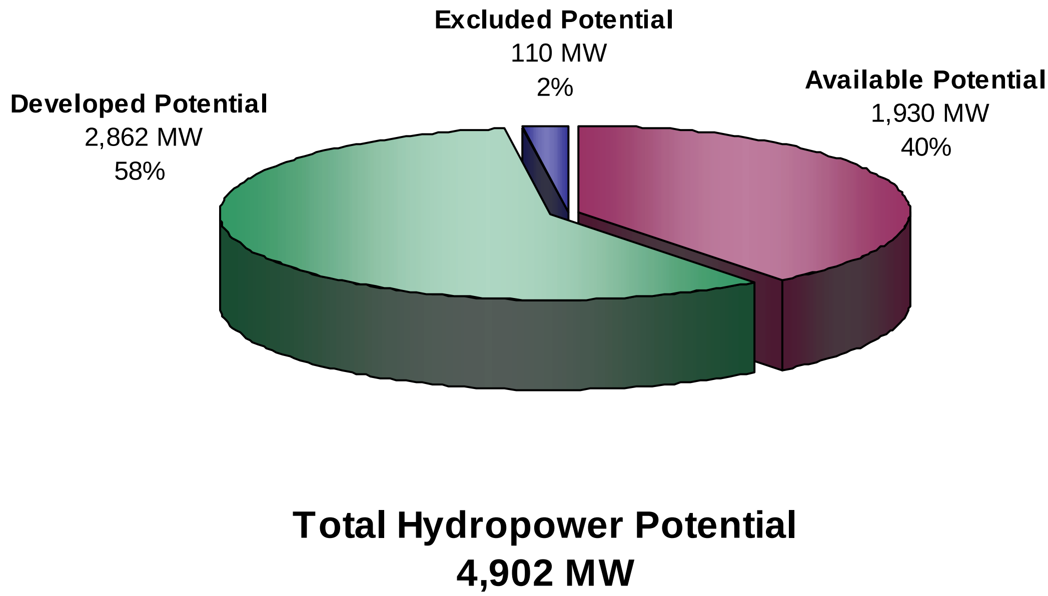


Figure B-147. Distribution of total hydropower potential in New York.

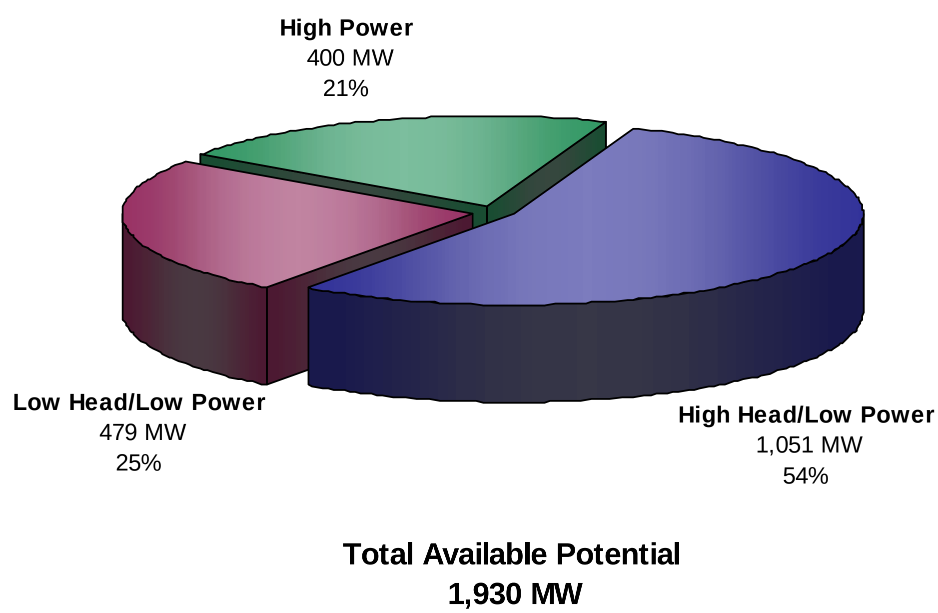


Figure B-148. Distribution of available hydropower potential in New York.

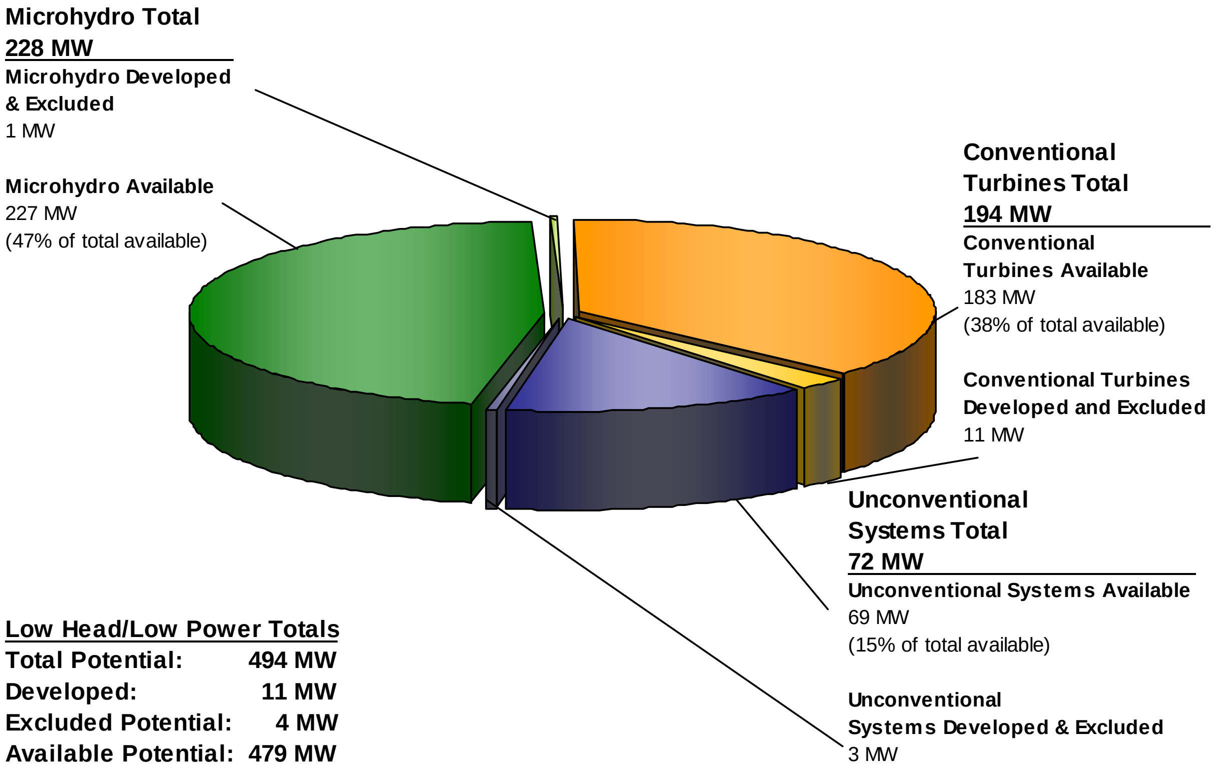


Figure B-149. Distribution of low head/low power hydropower potential in New York among three low head/low power hydropower technology classes.

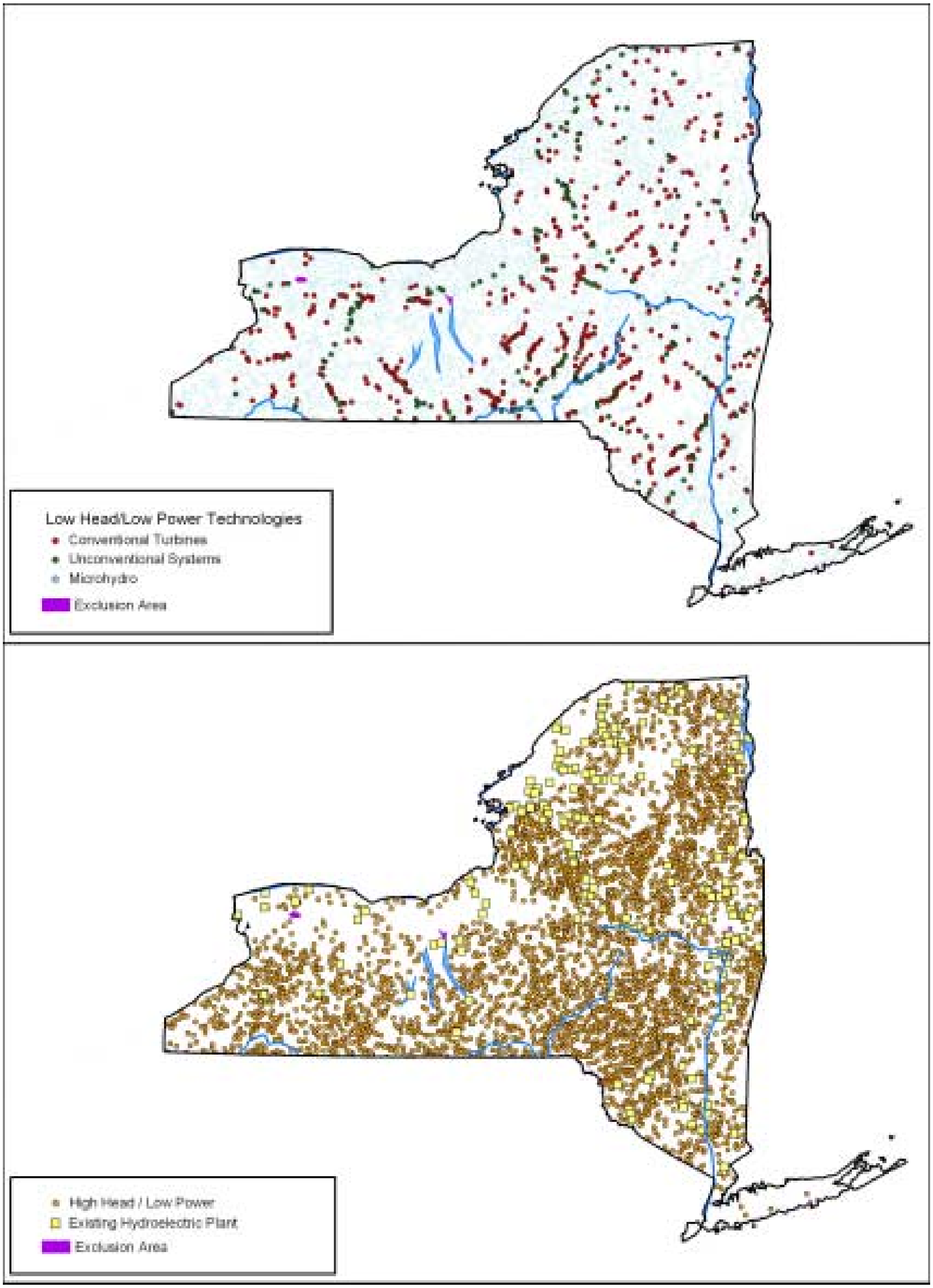


Figure B-150. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in New York.

B.31 North Carolina

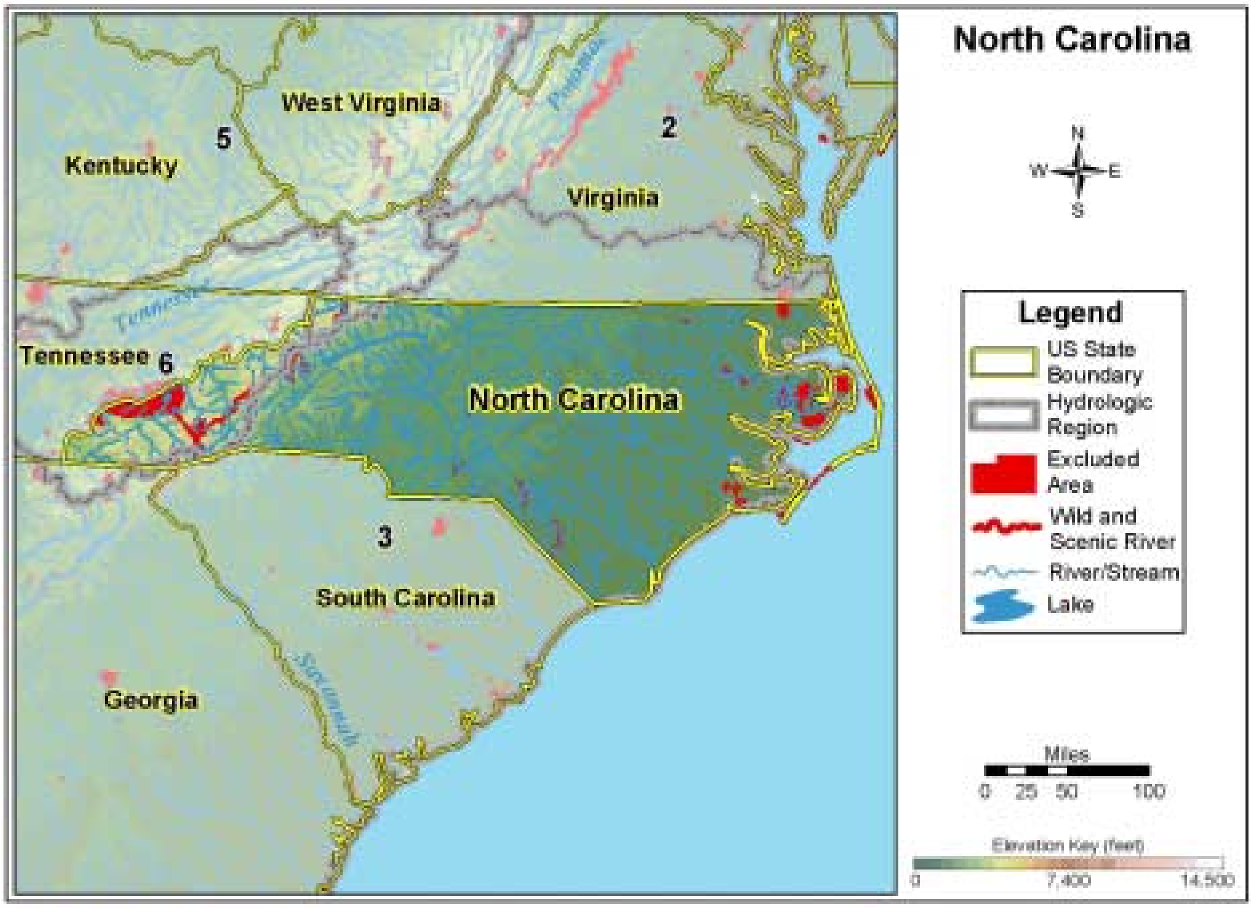


Figure B-151. North Carolina.

Table B-31. Summary of results of hydropower resource assessment of North Carolina.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**2,750**	**609**	**491**	**1,650**
TOTAL HIGH POWER	**1,896**	**603**	**389**	**904**
High Head/High Power	**1,615**	**596**	**369**	**650**
Low Head/High Power	**281**	**7**	**20**	**254**
TOTAL LOW POWER	**854**	**6**	**102**	**746**
High Head/Low Power	**470**	**2**	**86**	**382**
Low Head/Low Power	**384**	**4**	**16**	**364**
Conventional Turbine	131	4	7	120
Unconventional Systems	74	0	3	71
Microhydro	179	0	6	173

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

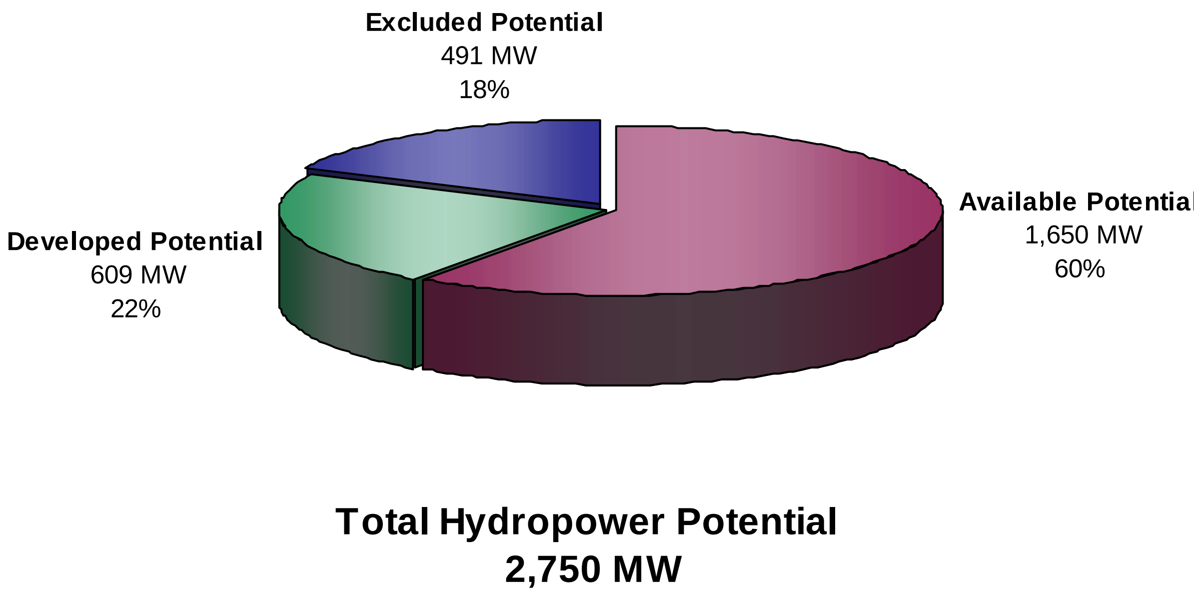


Figure B-152. Distribution of total hydropower potential in North Carolina.

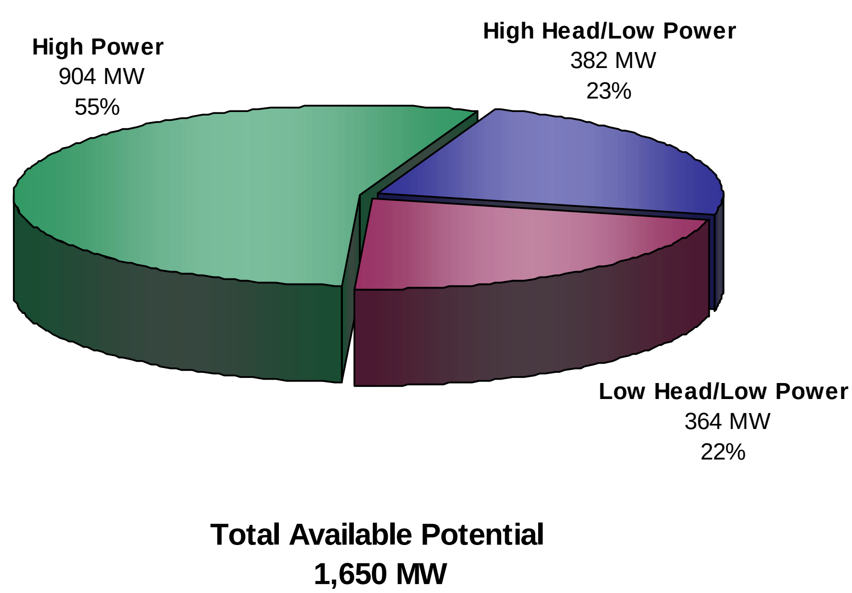


Figure B-153. Distribution of available hydropower potential in North Carolina.

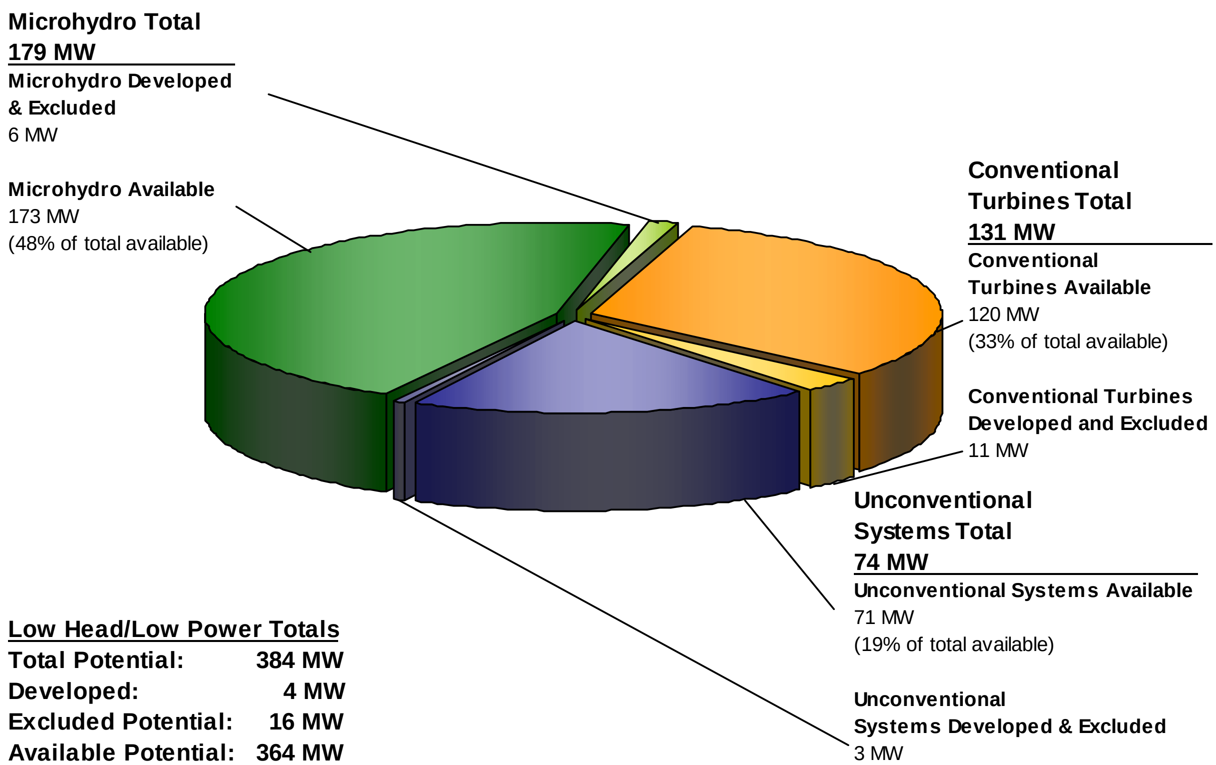


Figure B-154. Distribution of low head/low power hydropower potential in North Carolina among three low head/low power hydropower technology classes.

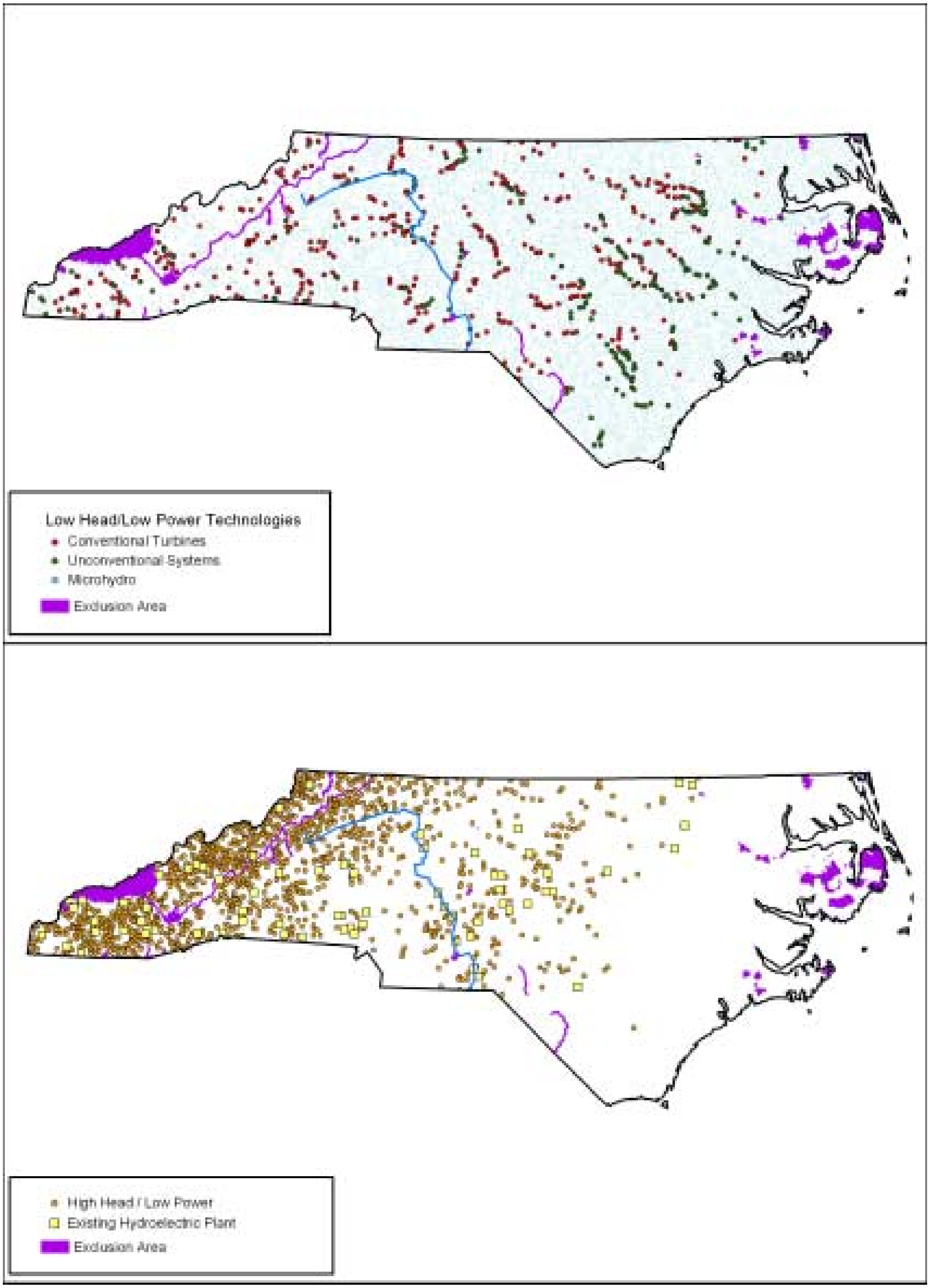


Figure B-155. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in North Carolina.

B.32 North Dakota

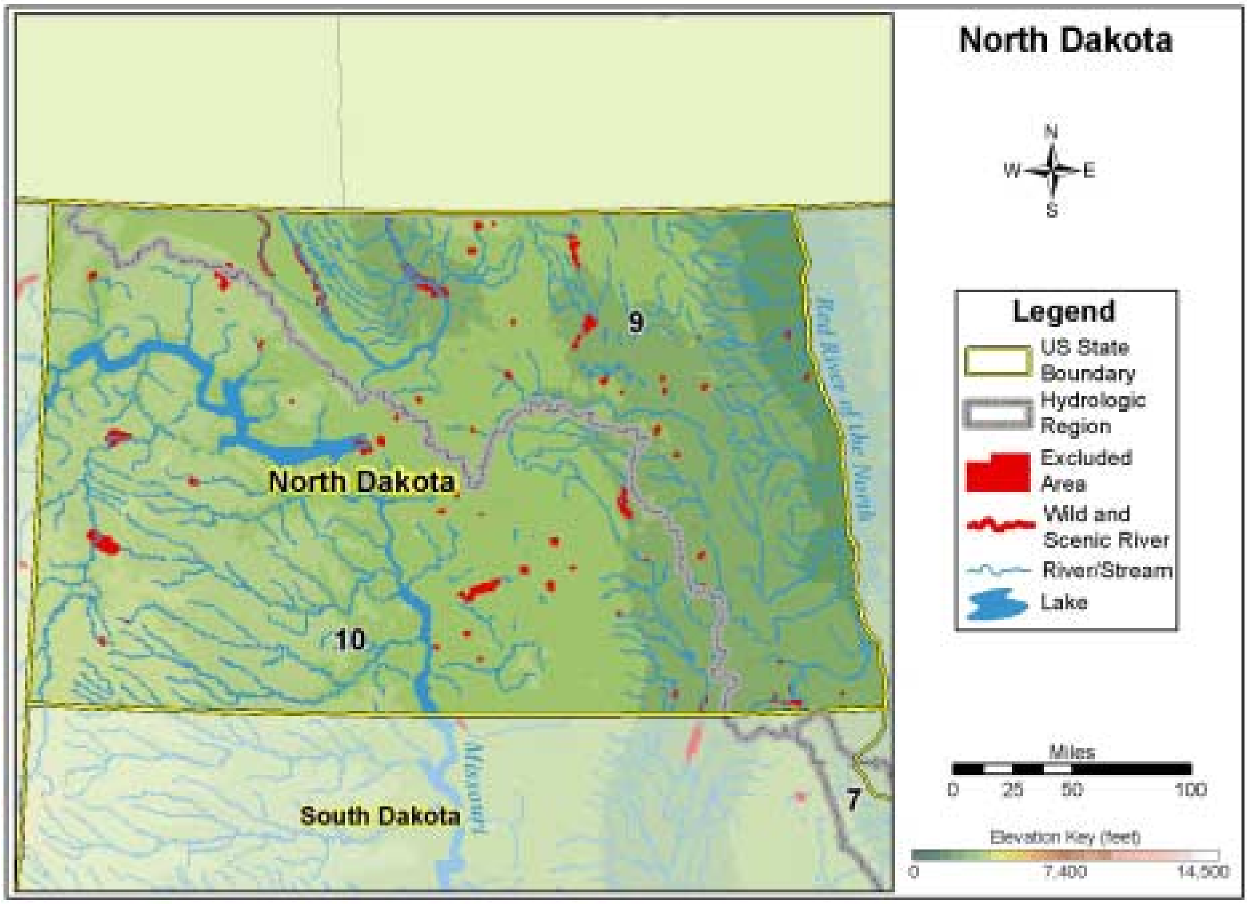


Figure B-156. North Dakota.

Table B-32. Summary of results of hydropower resource assessment of North Dakota.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**289**	**270**	**8**	**199**
TOTAL HIGH POWER	**132**	**270**	**4**	**46**
High Head/High Power	**82**	**270**	**0**	**—**
Low Head/High Power	**50**	**0**	**4**	**46**
TOTAL LOW POWER	**157**	**0**	**4**	**153**
High Head/Low Power	**15**	**0**	**0**	**15**
Low Head/Low Power	**142**	**0**	**4**	**138**
Conventional Turbine	37	0	2	35
Unconventional Systems	10	0	0	10
Microhydro	95	0	2	93

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

Note: Available high head/high power potential was negative possibly due to overestimation of developed potential. The available high head/high power value is considered unreasonable and is not included in the power class rollup. The total power and total high power available values are rolled up values that do not match the value obtained by horizontal summing of power category values.

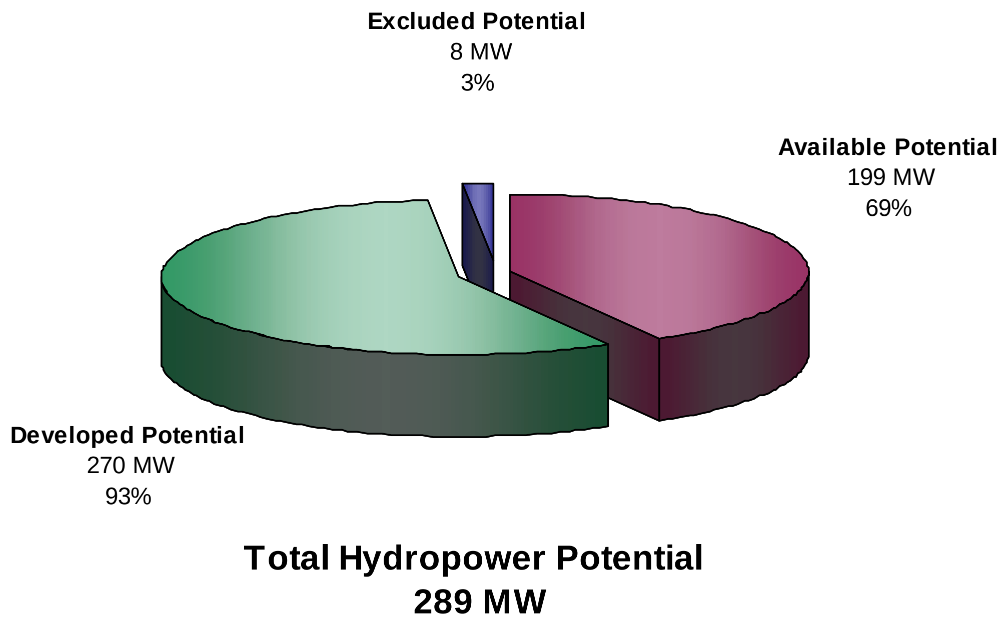


Figure B-157. Distribution of total hydropower potential in North Dakota.

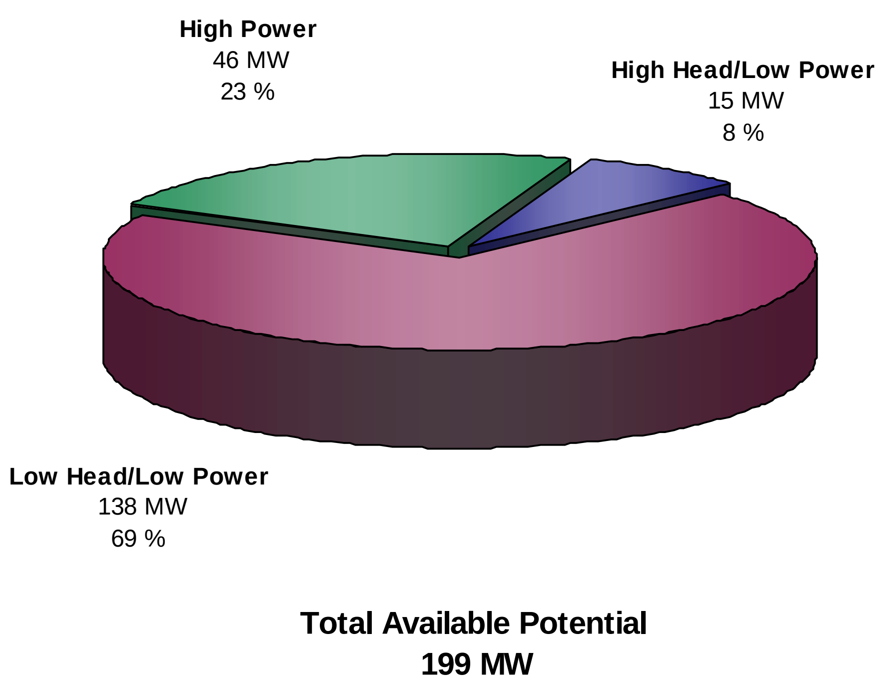


Figure B-158. Distribution of available hydropower potential in North Dakota.

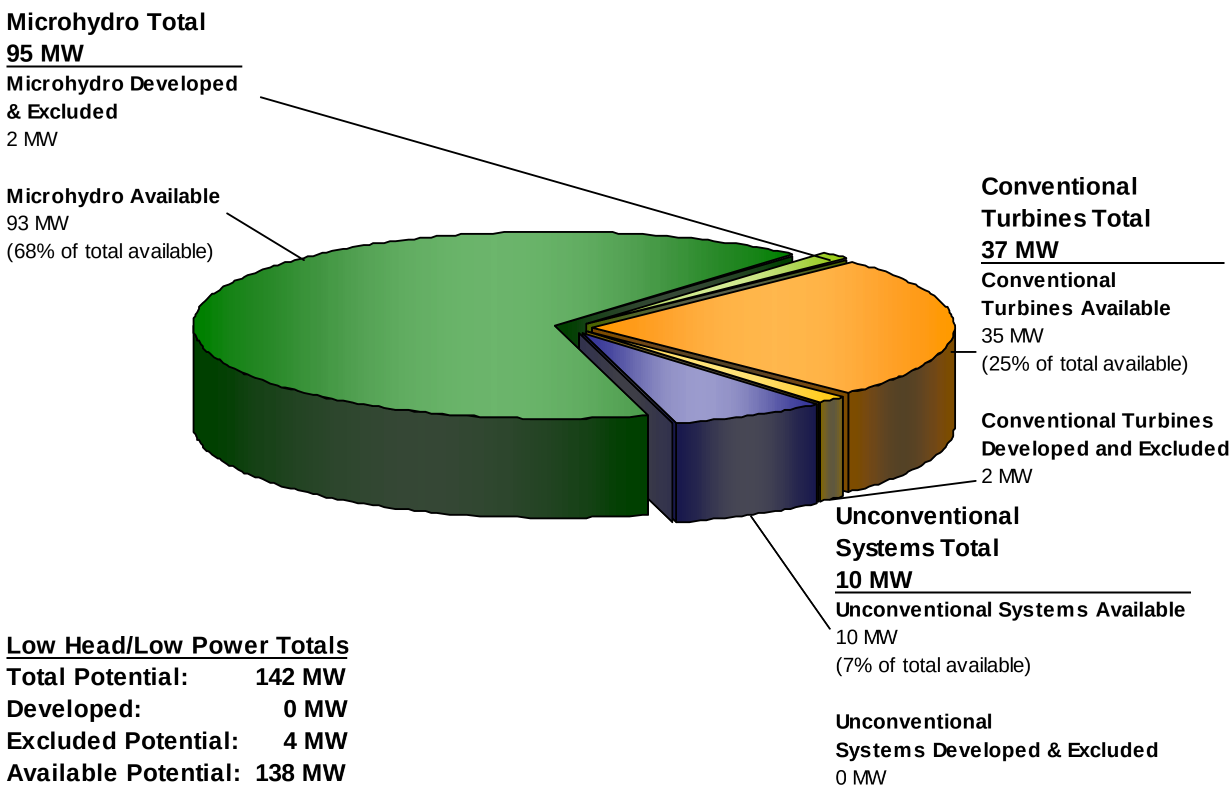


Figure B-159. Distribution of low head/low power hydropower potential in North Dakota among three low head/low power hydropower technology classes.

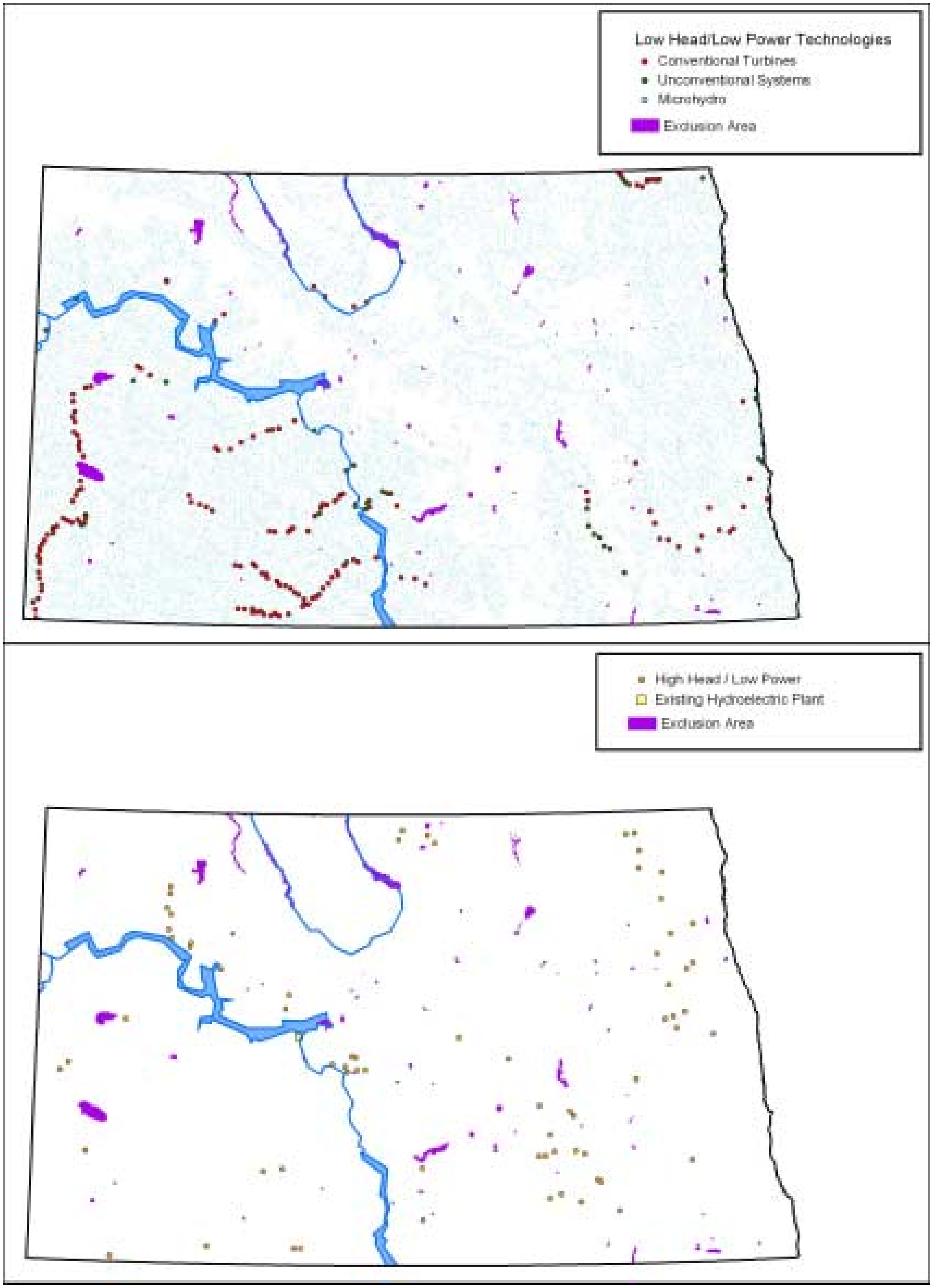


Figure B-160. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in North Dakota.

B.33 Ohio

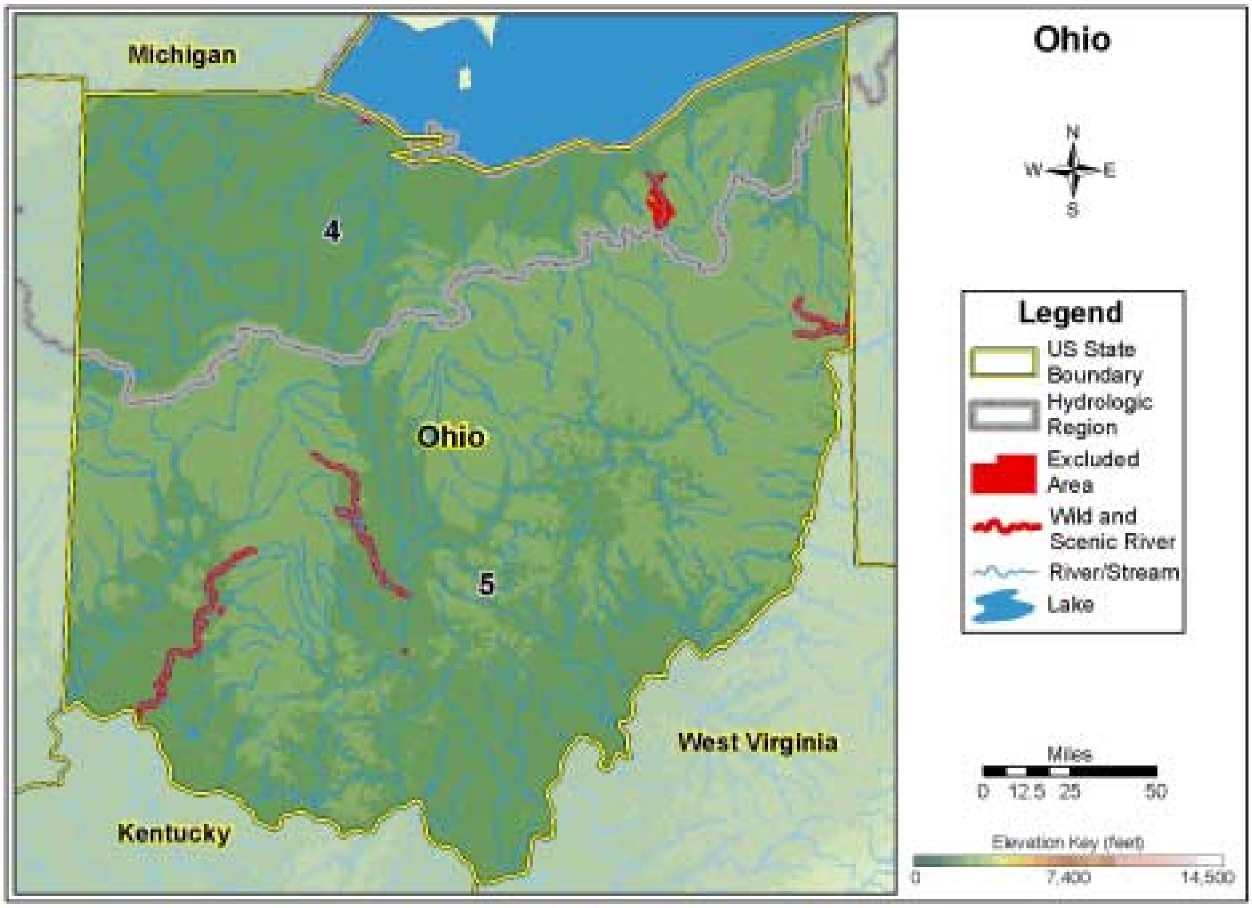


Figure B-161. Ohio.

Table B-33. Summary of results of hydropower resource assessment of Ohio.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,280**	**63**	**81**	**1,136**
TOTAL HIGH POWER	**718**	**63**	**51**	**604**
High Head/High Power	**151**	**36**	**18**	**97**
Low Head/High Power	**567**	**27**	**33**	**507**
TOTAL LOW POWER	**562**	**0**	**30**	**532**
High Head/Low Power	**150**	**0**	**6**	**144**
Low Head/Low Power	**412**	**0**	**24**	**388**
Conventional Turbine	167	0	15	152
Unconventional Systems	57	0	3	54
Microhydro	188	0	6	182

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

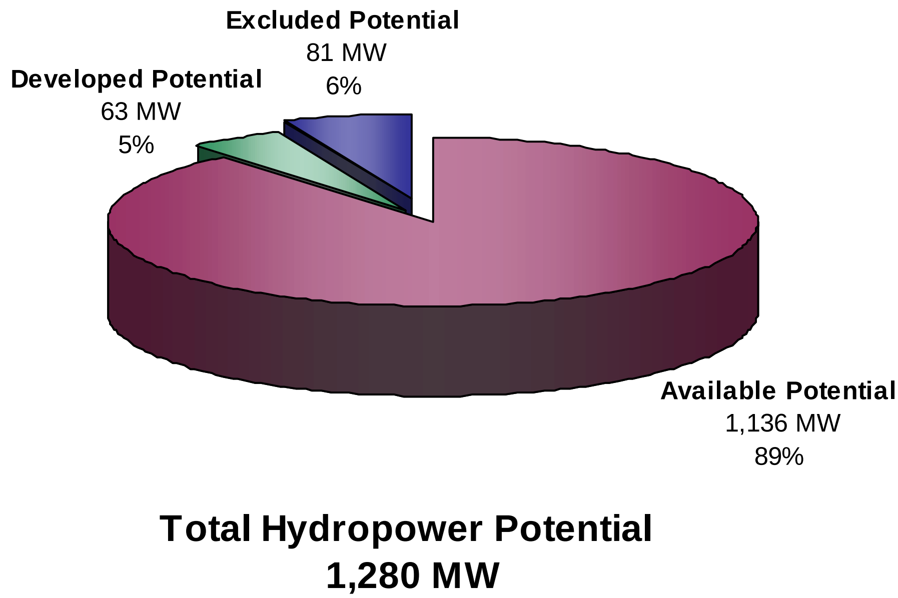


Figure B-162. Distribution of total hydropower potential in Ohio.

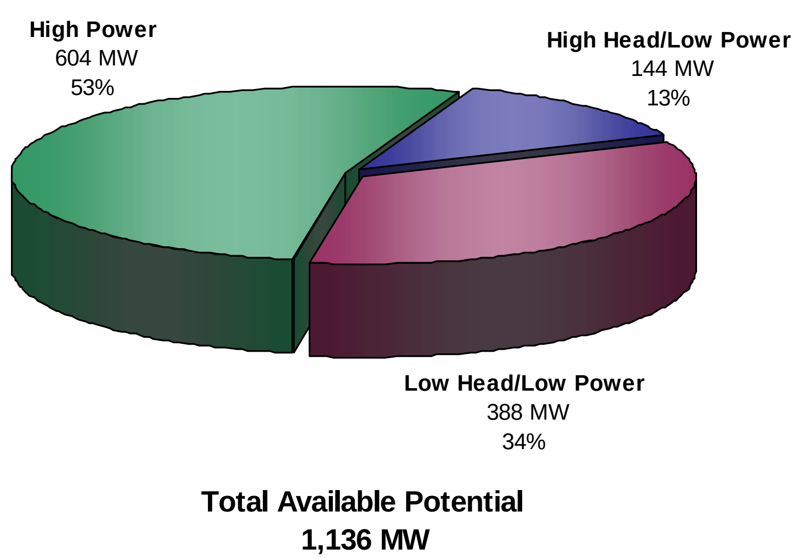


Figure B-163. Distribution of available hydropower potential in Ohio.

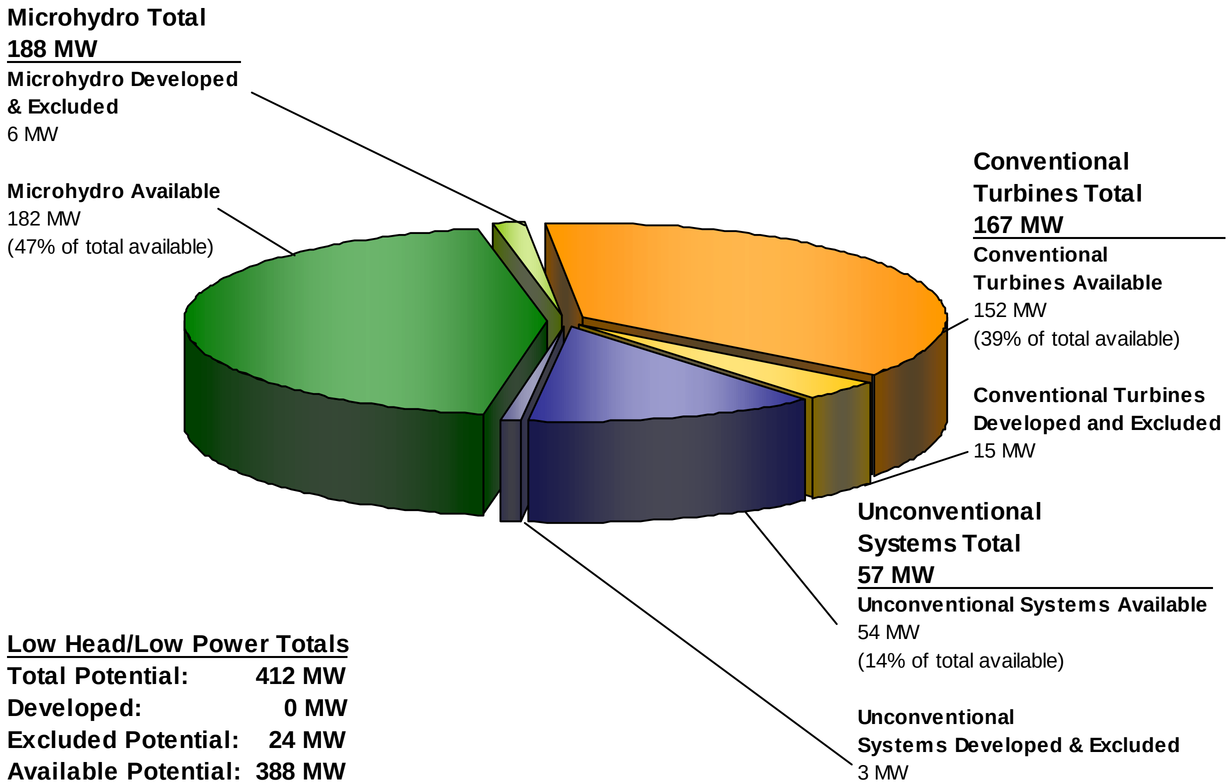


Figure B-164. Distribution of low head/low power hydropower potential in Ohio among three low head/low power hydropower technology classes.

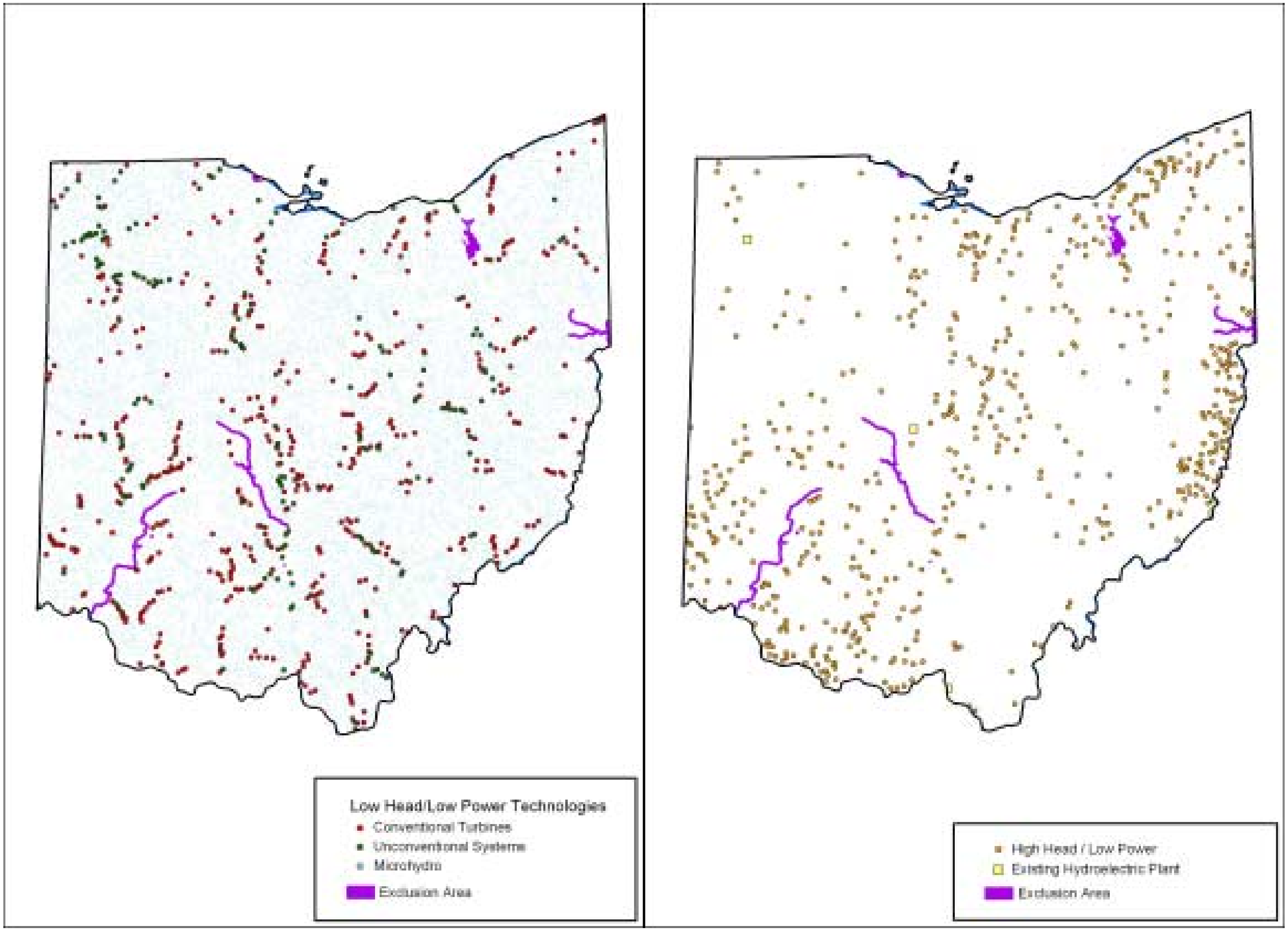


Figure B-165. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Ohio.

B.34 Oklahoma

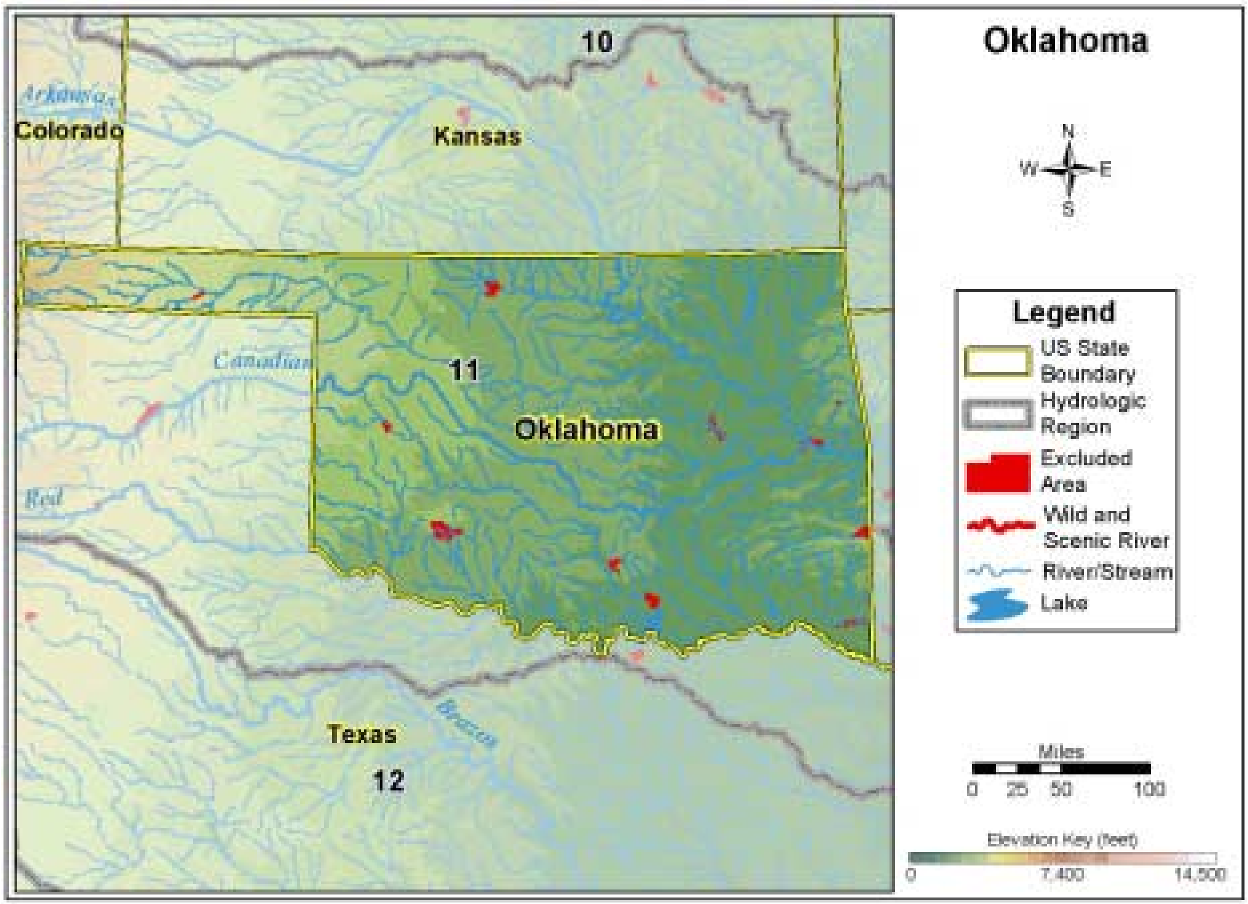


Figure B-166. Oklahoma.

Table B-34. Summary of results of hydropower resource assessment of Oklahoma.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,511**	**239**	**23**	**1,249**
TOTAL HIGH POWER	**725**	**239**	**5**	**481**
High Head/High Power	**323**	**239**	**1**	**83**
Low Head/High Power	**402**	**0**	**4**	**398**
TOTAL LOW POWER	**786**	**0**	**18**	**768**
High Head/Low Power	**120**	**0**	**6**	**114**
Low Head/Low Power	**666**	**0**	**12**	**654**
Conventional Turbine	286	0	4	282
Unconventional Systems	157	0	5	152
Microhydro	223	0	3	220

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

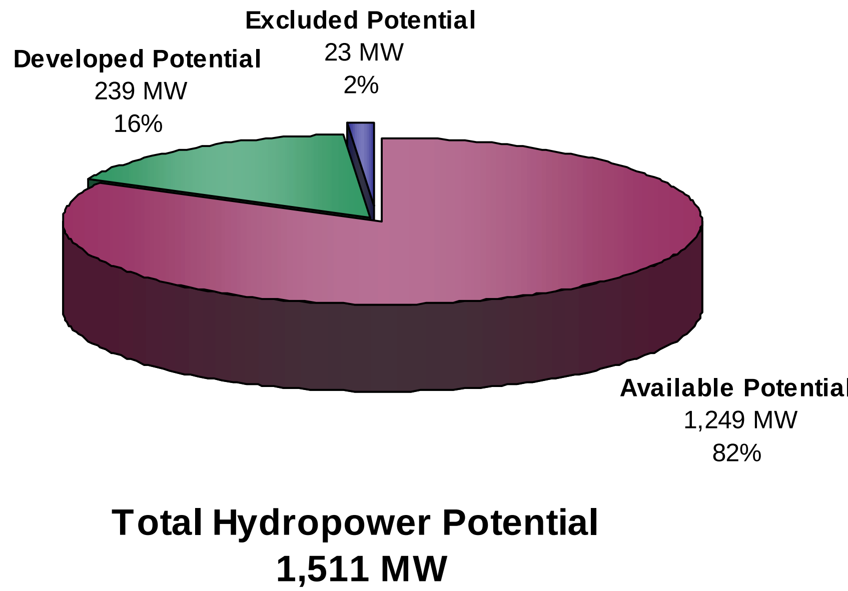


Figure B-167. Distribution of total hydropower potential in Oklahoma.

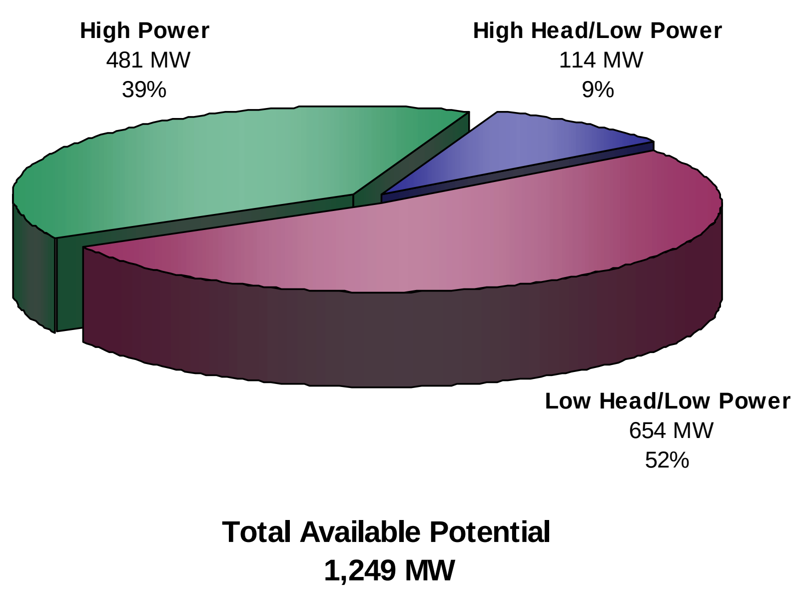


Figure B-168. Distribution of available hydropower potential in Oklahoma.

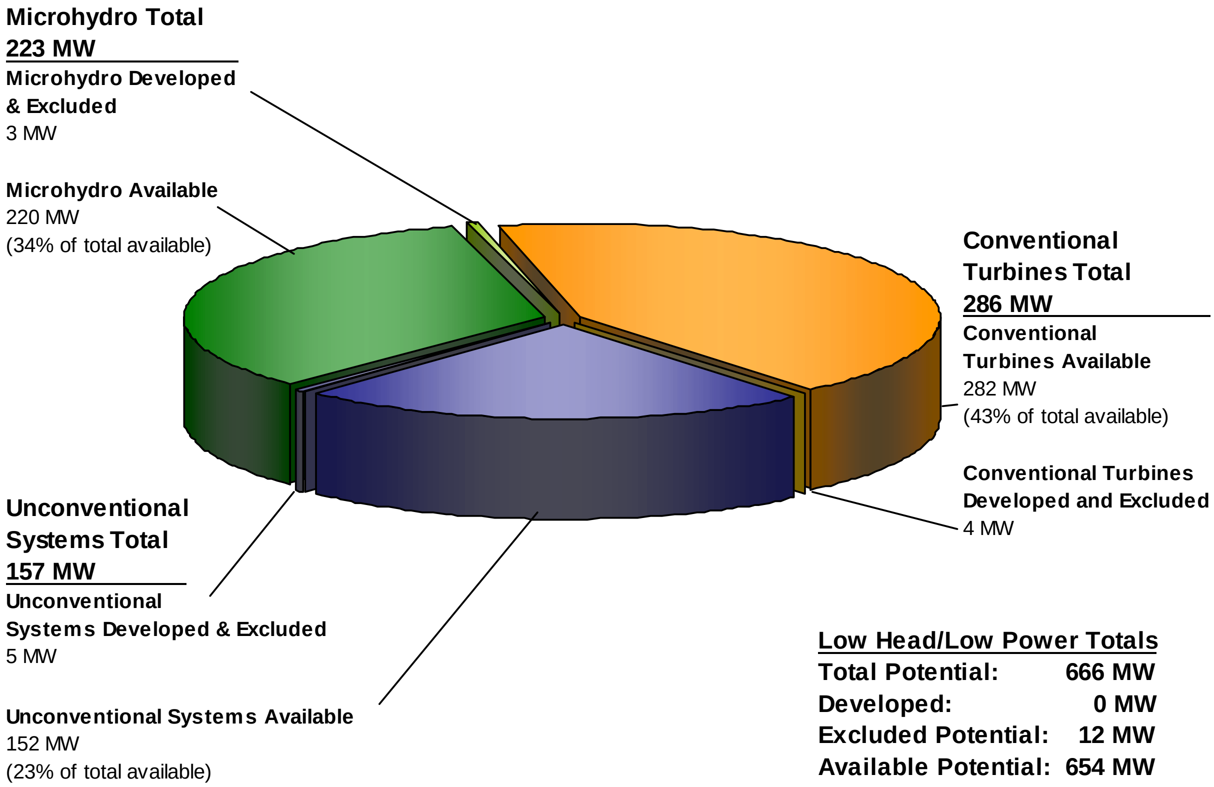
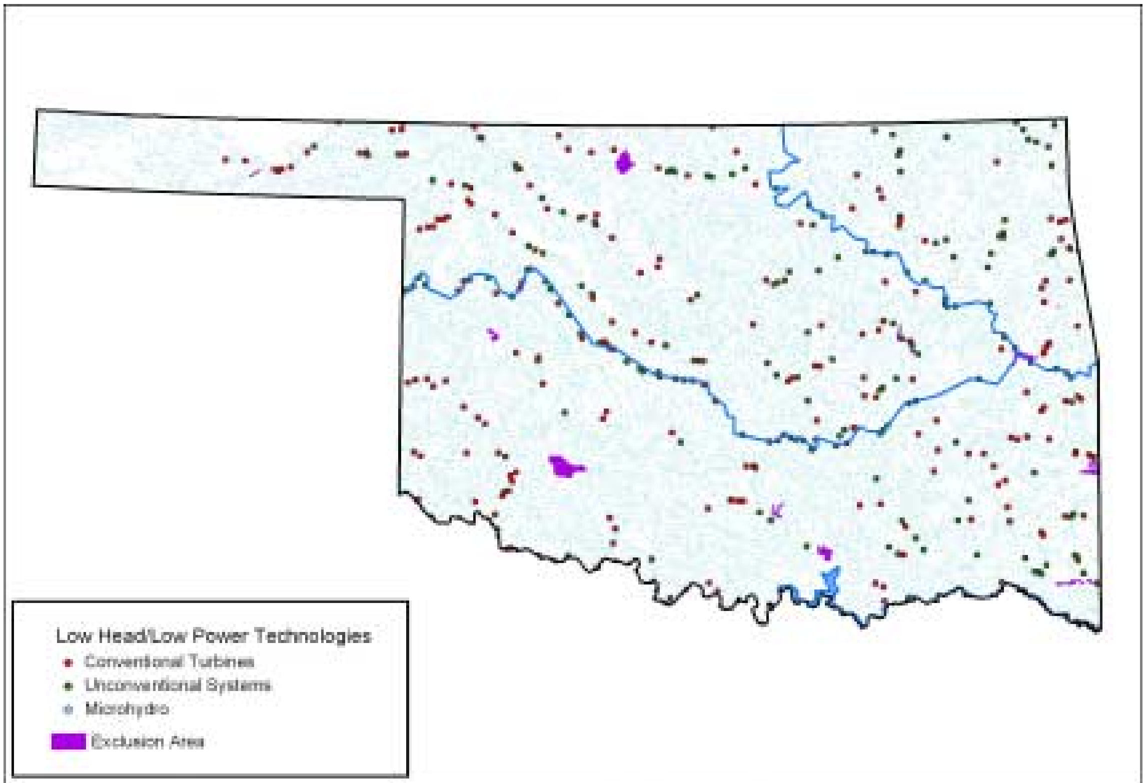


Figure B-169. Distribution of low head/low power hydropower potential in Oklahoma among three low head/low power hydropower technology classes.



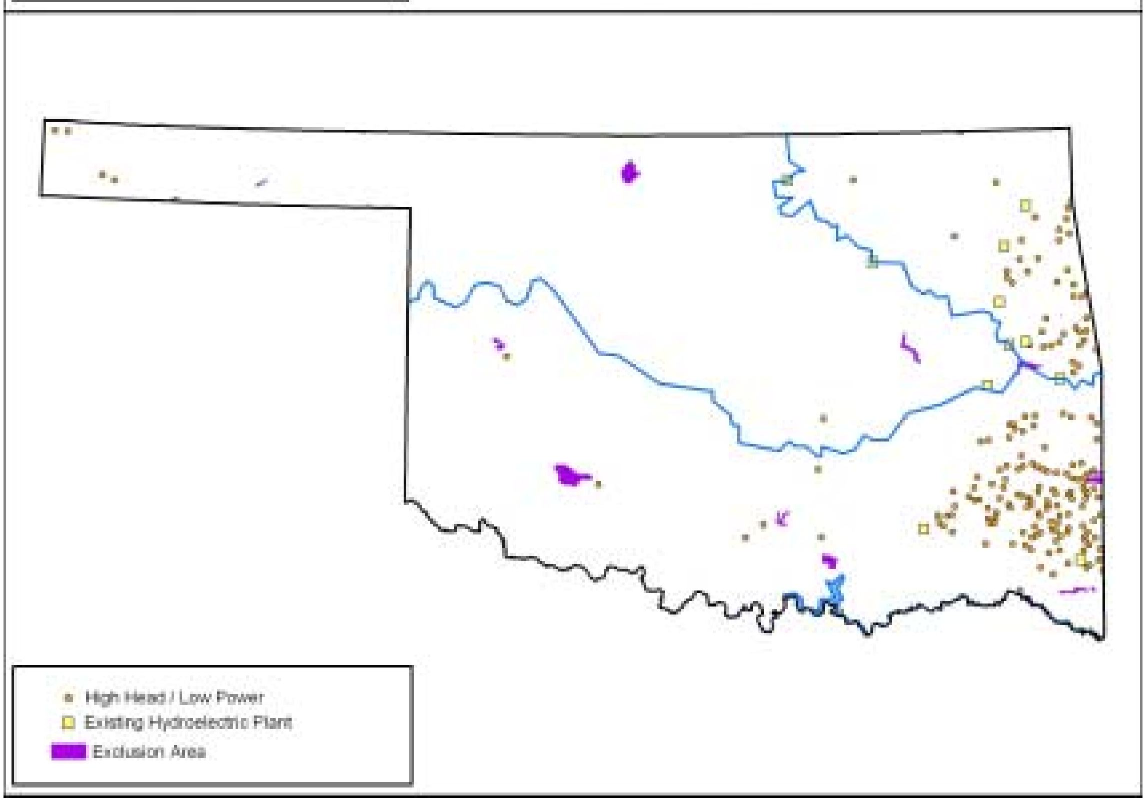


Figure B-170. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Oklahoma.

B.35 Oregon

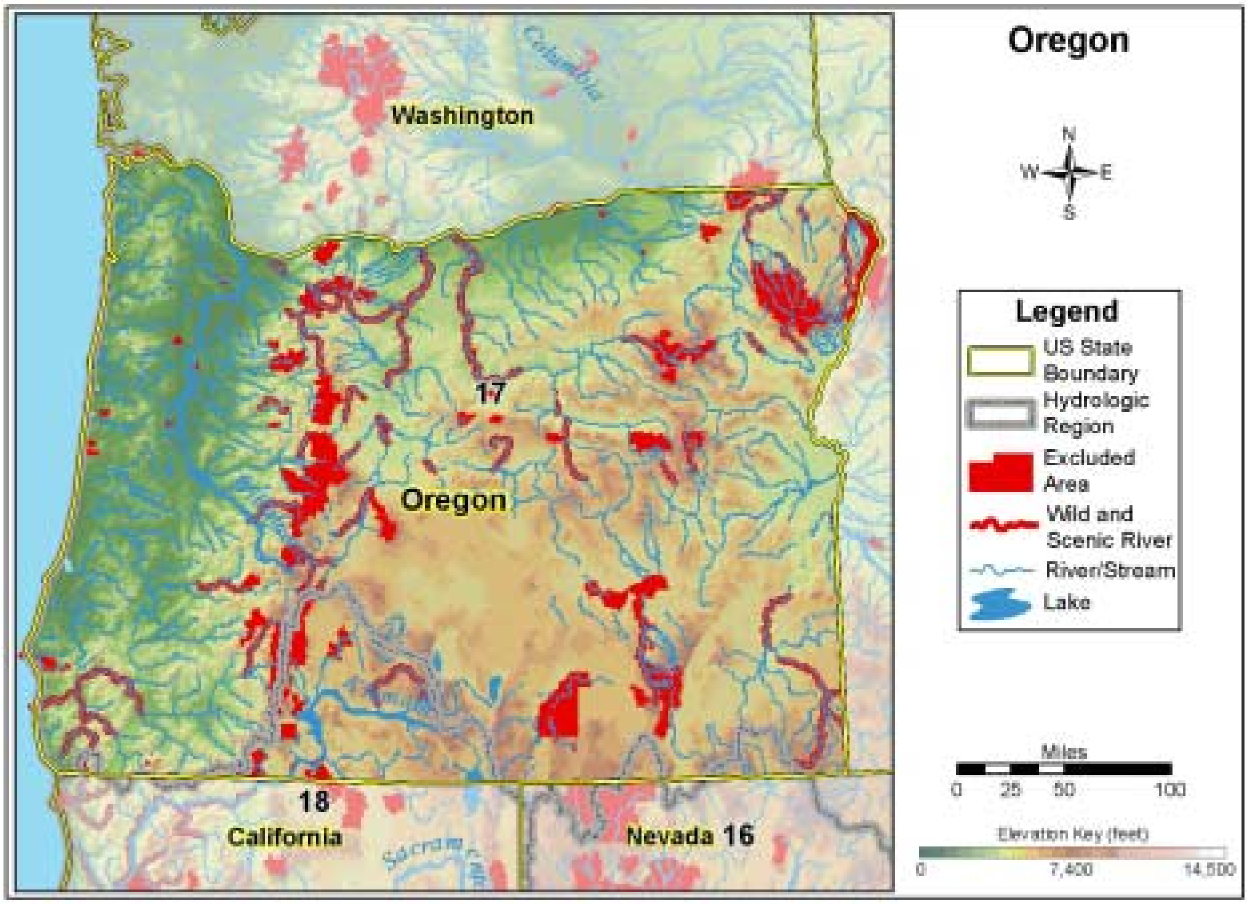


Figure B-171. Oregon.

Table B-35. Summary of results of hydropower resource assessment of Oregon.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**18,397**	**3,296**	**5,835**	**9,266**
TOTAL HIGH POWER	**15,341**	**3,292**	**5,391**	**6,658**
High Head/High Power	**12,862**	**3,291**	**4,377**	**5,194**
Low Head/High Power	**2,479**	**1**	**1,014**	**1,464**
TOTAL LOW POWER	**3,056**	**4**	**444**	**2,608**
High Head/Low Power	**2,307**	**4**	**366**	**1,937**
Low Head/Low Power	**749**	**0**	**78**	**671**
Conventional Turbine	259	0	29	230
Unconventional Systems	111	0	22	89
Microhydro	379	0	27	352

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

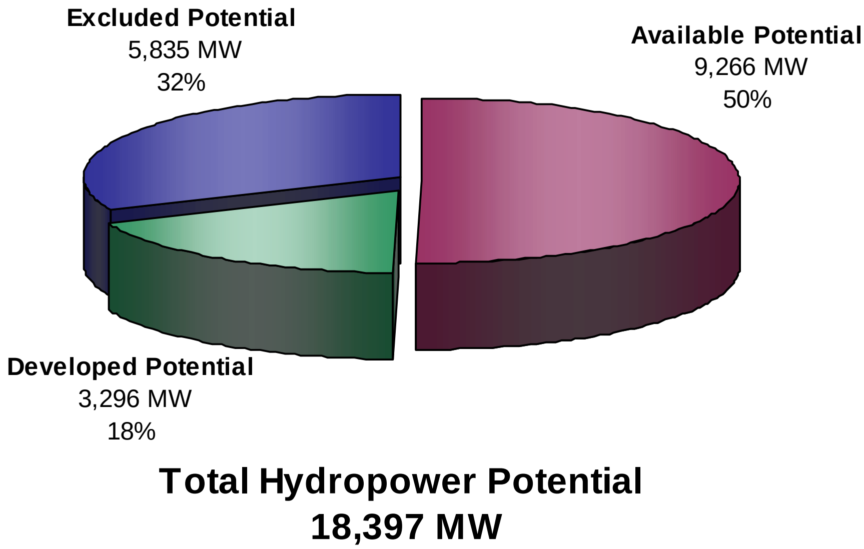


Figure B-172. Distribution of total hydropower potential in Oregon.

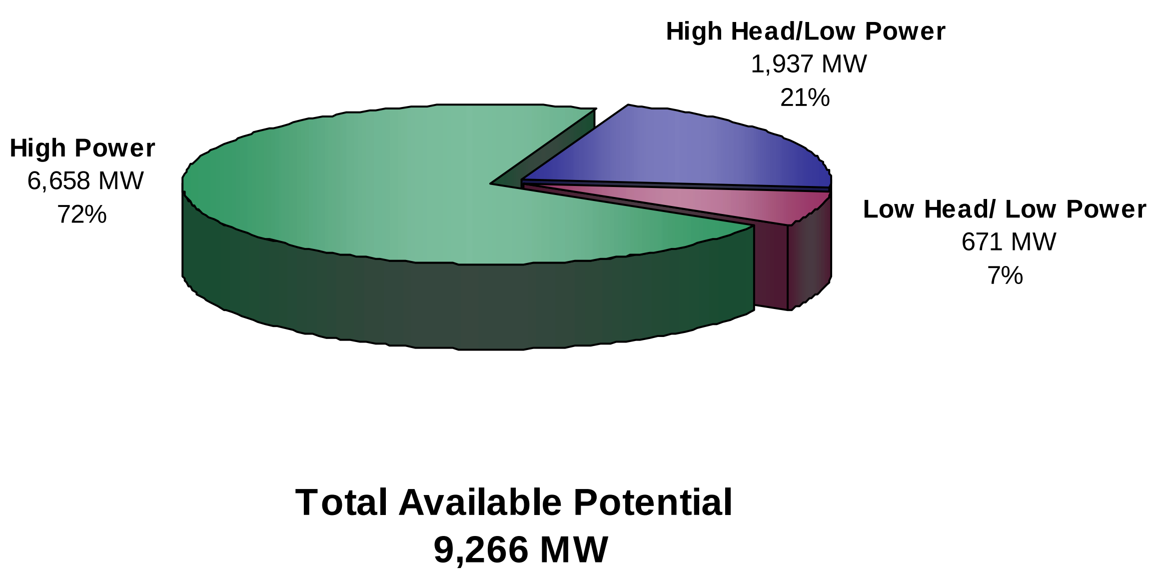


Figure B-173. Distribution of available hydropower potential in Oregon.

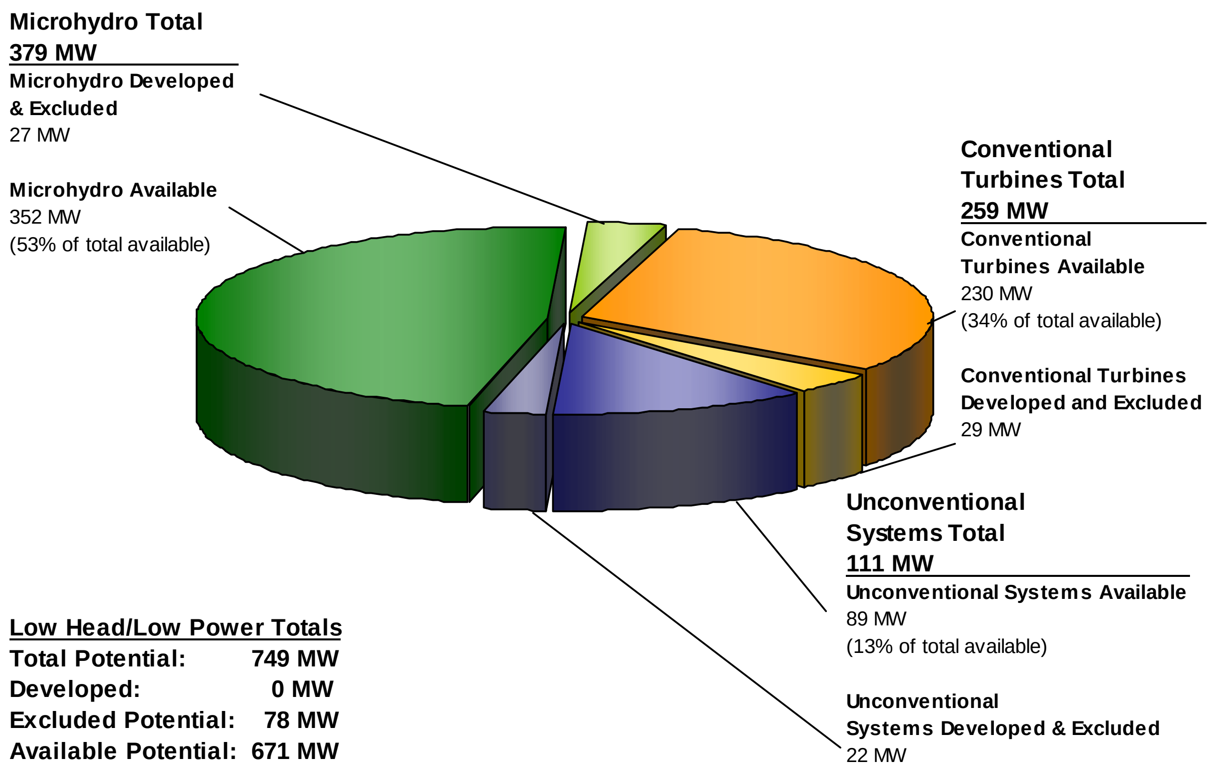


Figure B-174. Distribution of low head/low power hydropower potential in Oregon among three low head/low power hydropower technology classes.

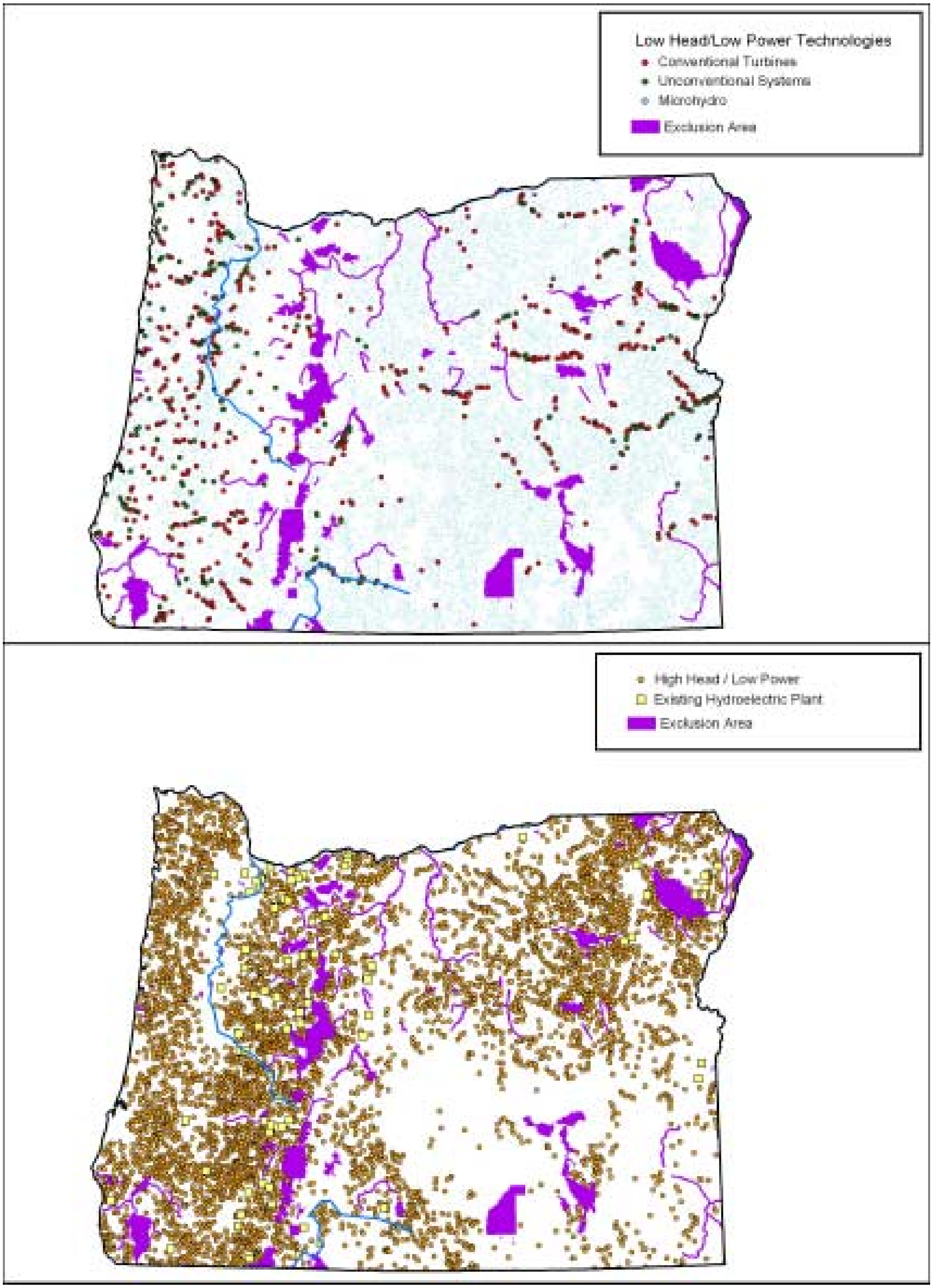


Figure B-175. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Oregon.

B.36 Pennsylvania

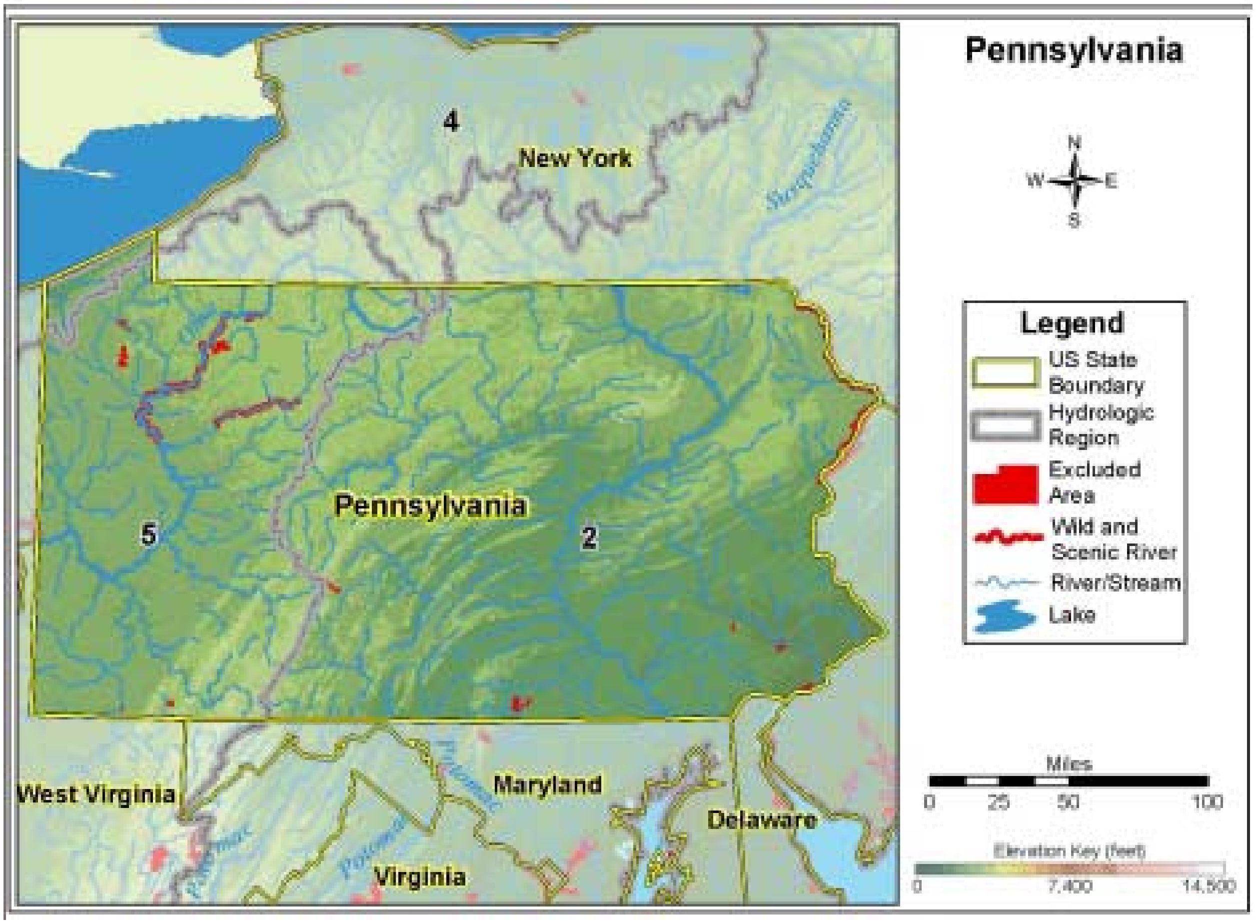


Figure B-176. Pennsylvania.

Table B-36. Summary of results of hydropower resource assessment of Pennsylvania.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**4,754**	**284**	**488**	**3,982**
TOTAL HIGH POWER	**3,265**	**283**	**448**	**2,534**
High Head/High Power	**1,570**	**233**	**182**	**1,155**
Low Head/High Power	**1,695**	**50**	**266**	**1,379**
TOTAL LOW POWER	**1,489**	**1**	**40**	**1,448**
High Head/Low Power	**980**	**1**	**30**	**949**
Low Head/Low Power	**509**	**0**	**10**	**499**
Conventional Turbine	190	0	4	186
Unconventional Systems	59	0	3	56
Microhydro	260	0	3	257

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

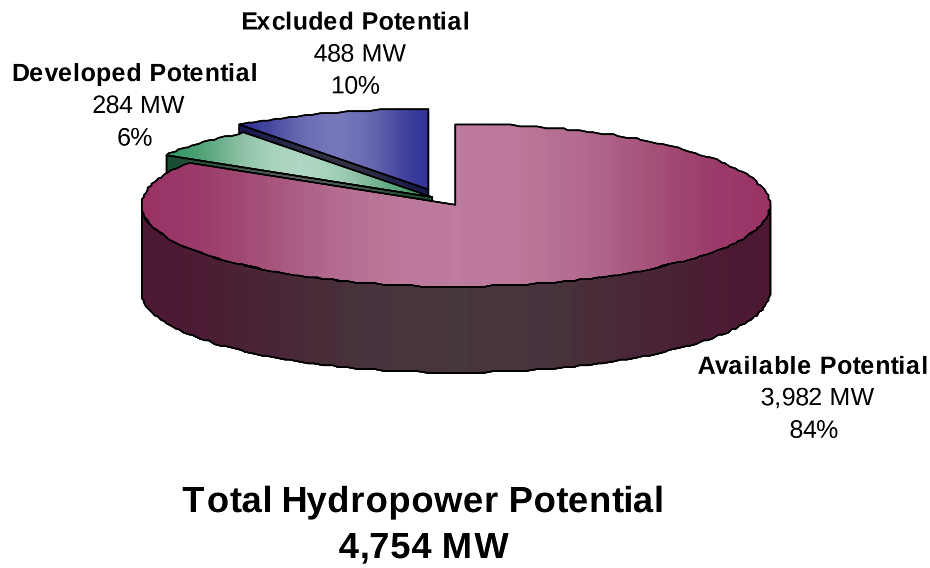


Figure B-177. Distribution of total hydropower potential in Pennsylvania.

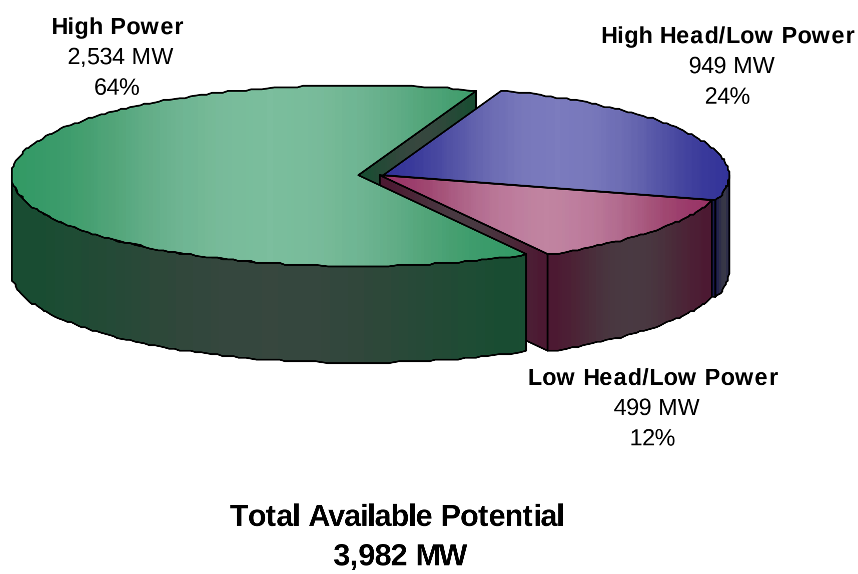


Figure B-178. Distribution of available hydropower potential in Pennsylvania.

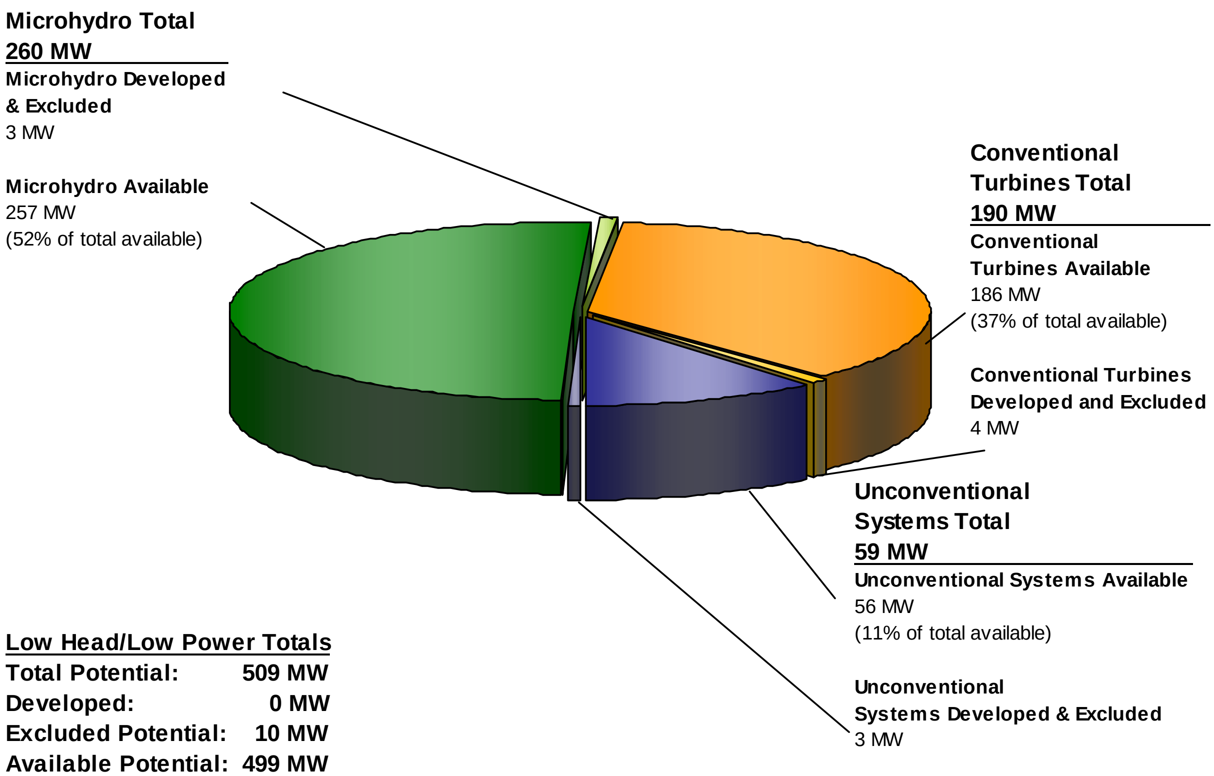


Figure B-179. Distribution of low head/low power hydropower potential in Pennsylvania among three low head/low power hydropower technology classes.

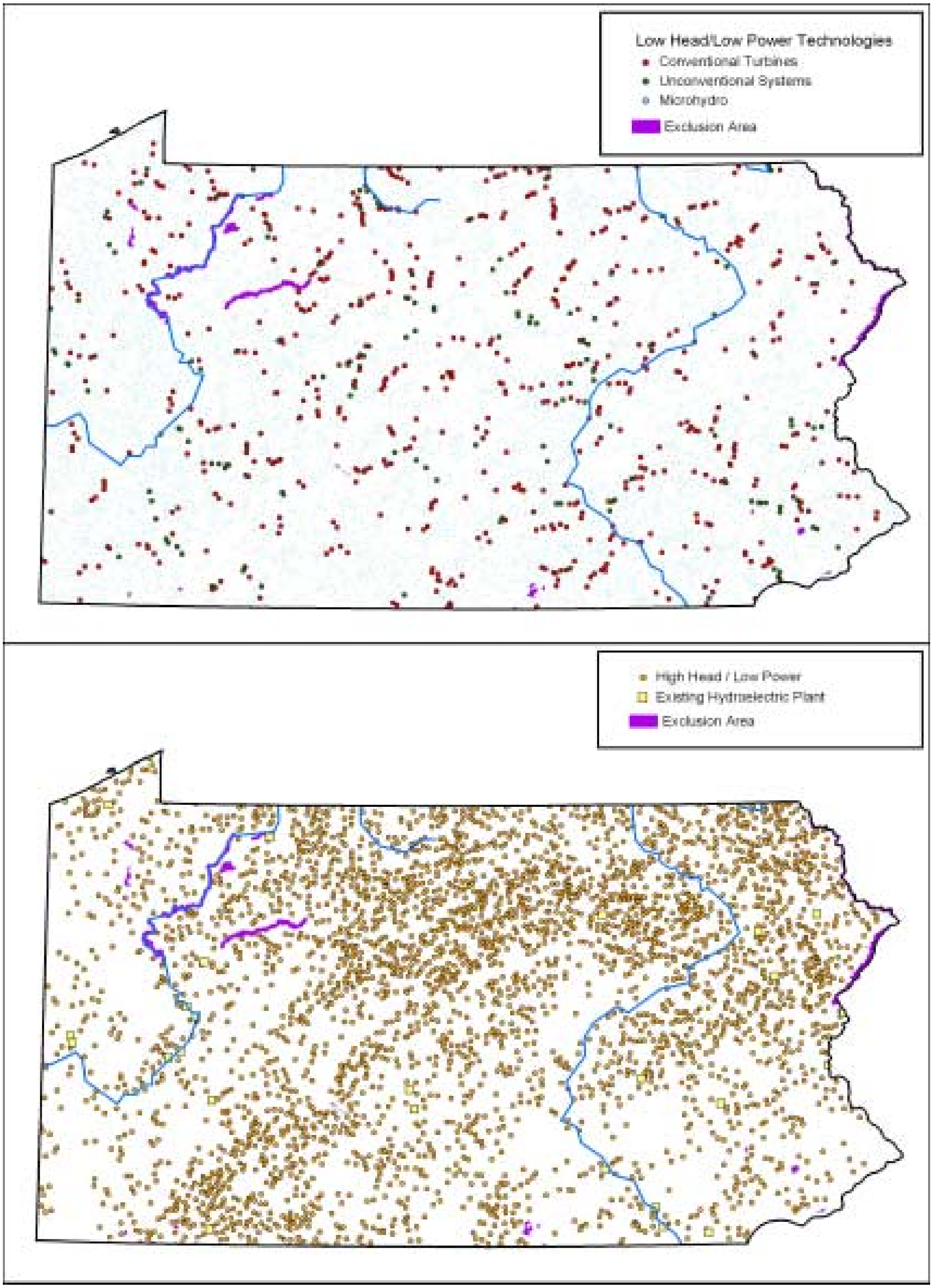


Figure B-180. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Pennsylvania.

B.37 Rhode Island

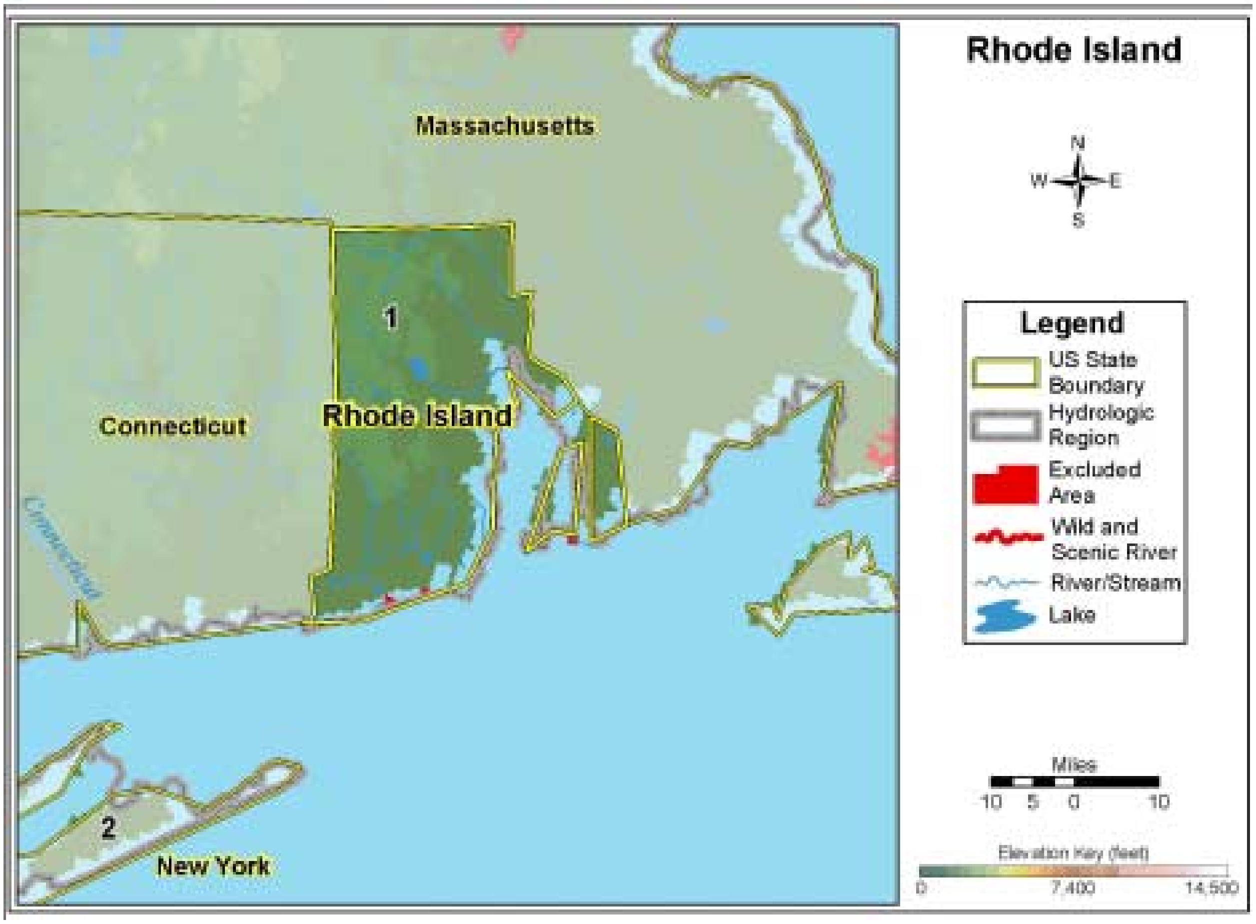


Figure B-181. Rhode Island.

Table B-37. Summary of results of hydropower resource assessment of Rhode Island.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**37**	**3**	**0**	**34**
TOTAL HIGH POWER	**16**	**2**	**0**	**14**
High Head/High Power	**14**	**1**	**0**	**13**
Low Head/High Power	**2**	**1**	**0**	**1**
TOTAL LOW POWER	**21**	**1**	**0**	**20**
High Head/Low Power	**9**	**0**	**0**	**9**
Low Head/Low Power	**12**	**1**	**0**	**11**
Conventional Turbine	5	1	0	4
Unconventional Systems	1	0	0	1
Microhydro	6	0	0	6

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

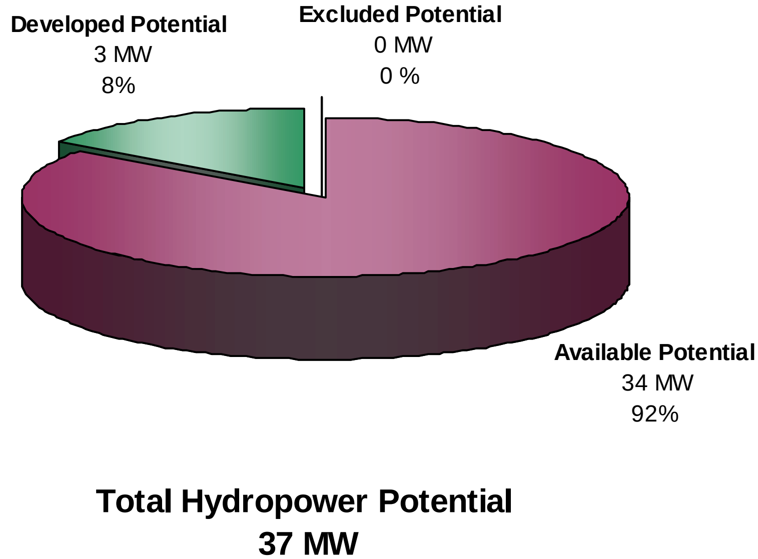


Figure B-182. Distribution of total hydropower potential in Rhode Island.

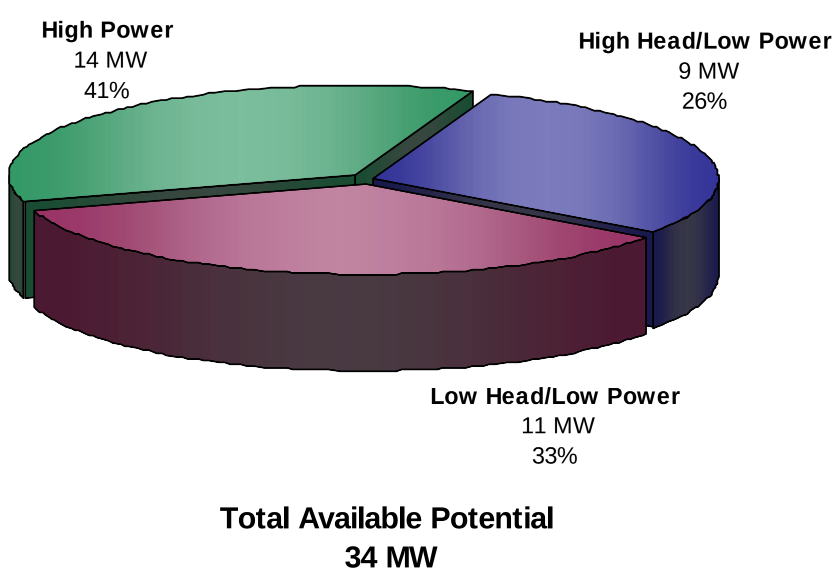


Figure B-183. Distribution of available hydropower potential in Rhode Island.

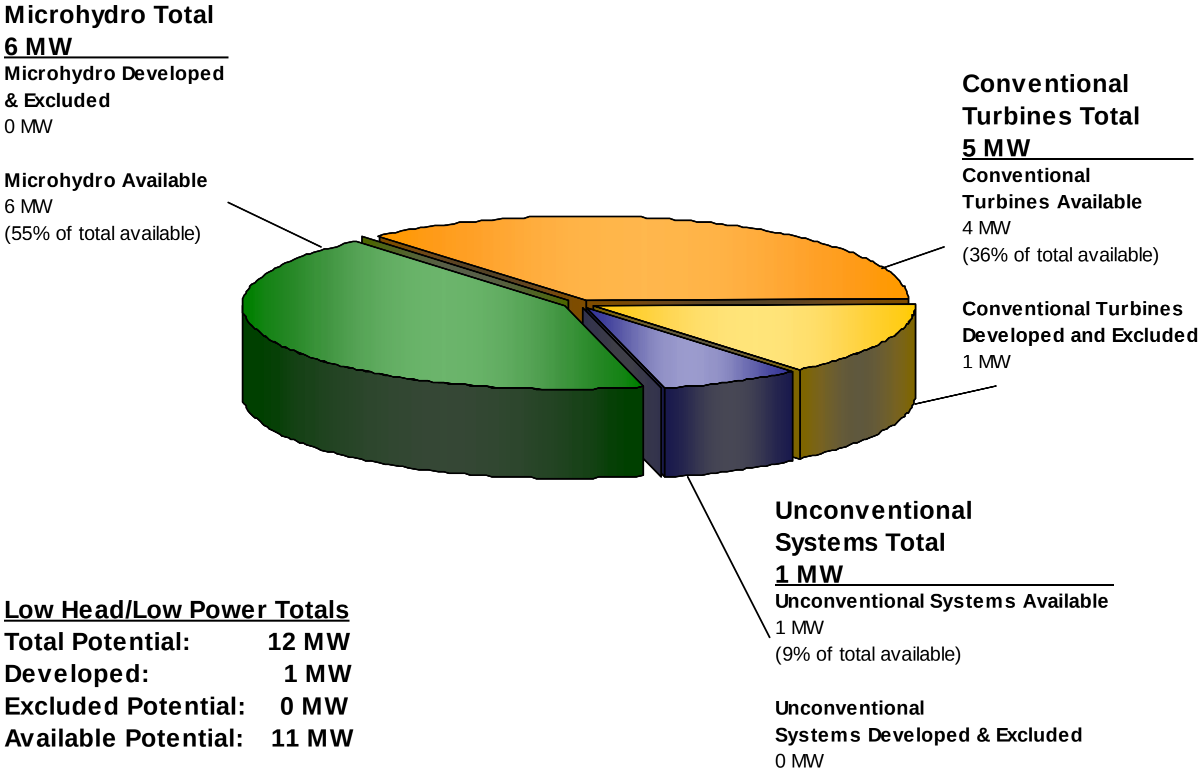


Figure B-184. Distribution of low head/low power hydropower potential in Rhode Island among three low head/low power hydropower technology classes.

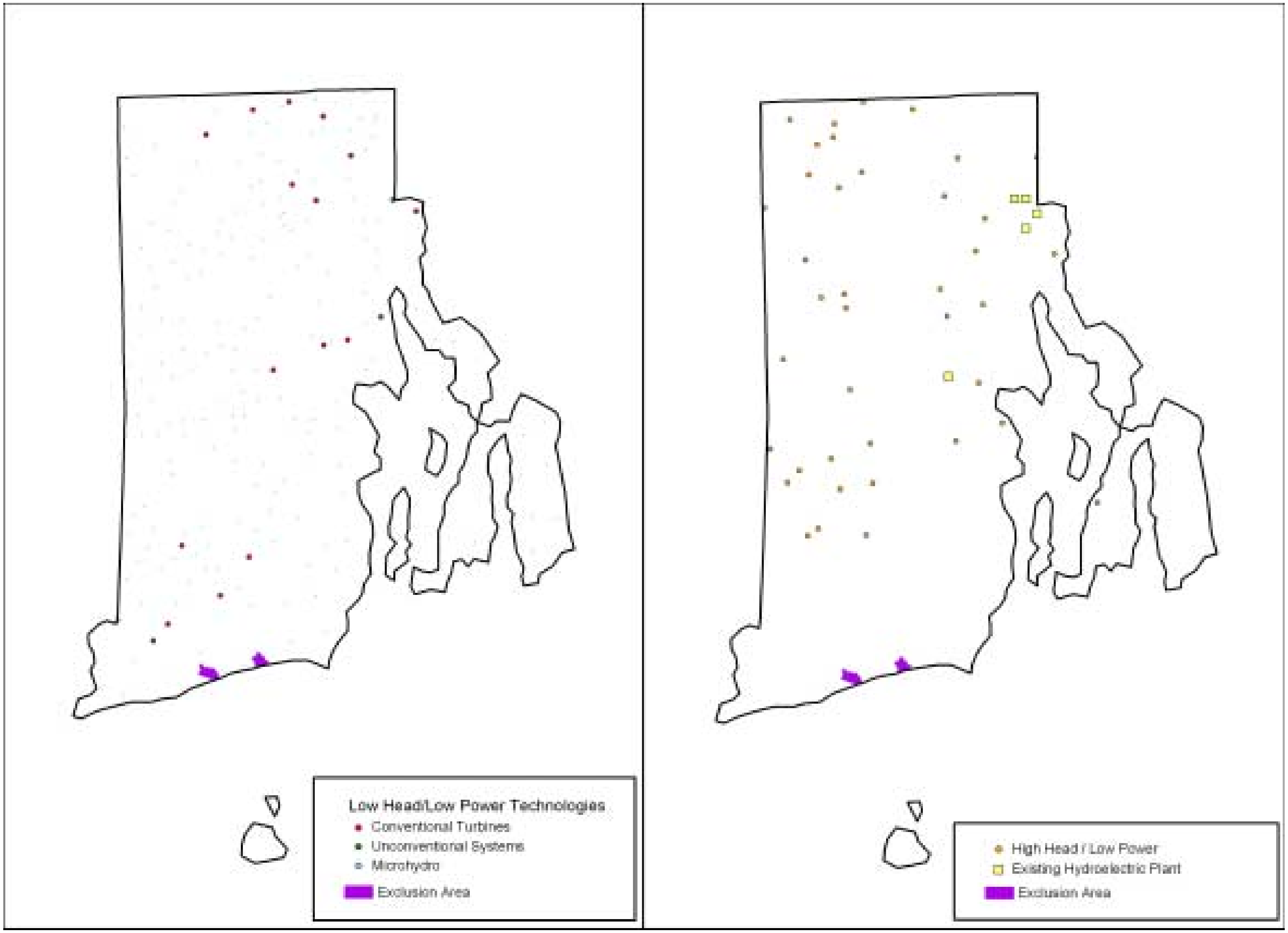


Figure B-185. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Rhode Island.

B.38 South Carolina

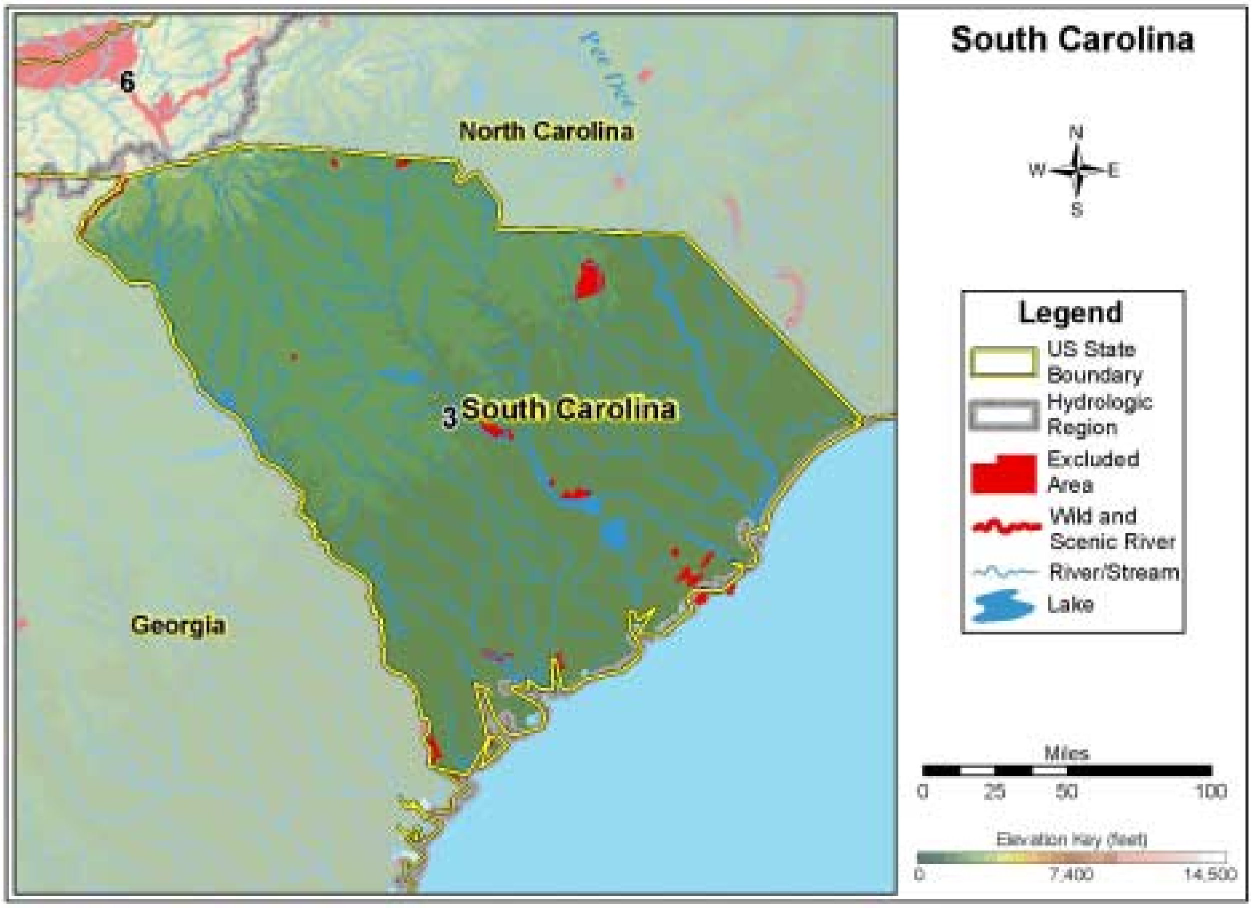


Figure B-186. South Carolina.

Table B-38. Summary of results of hydropower resource assessment of South Carolina.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,325**	**430**	**49**	**846**
TOTAL HIGH POWER	**972**	**426**	**43**	**503**
High Head/High Power	**487**	**419**	**28**	**40**
Low Head/High Power	**485**	**7**	**15**	**463**
TOTAL LOW POWER	**353**	**4**	**6**	**343**
High Head/Low Power	**86**	**2**	**3**	**81**
Low Head/Low Power	**267**	**2**	**3**	**262**
Conventional Turbine	72	2	0	70
Unconventional Systems	81	0	2	79
Microhydro	114	0	1	113

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

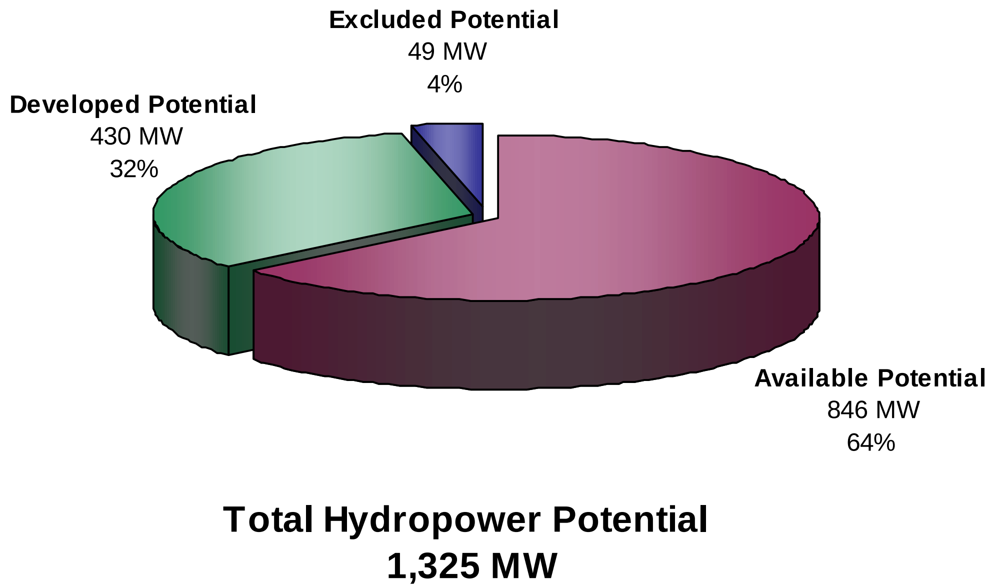


Figure B-187. Distribution of total hydropower potential in South Carolina.

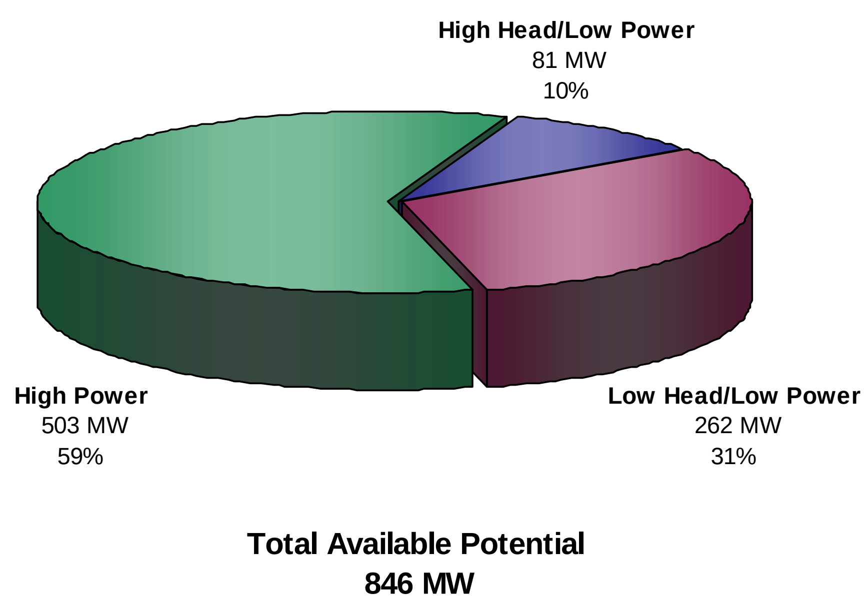


Figure B-188. Distribution of available hydropower potential in South Carolina.

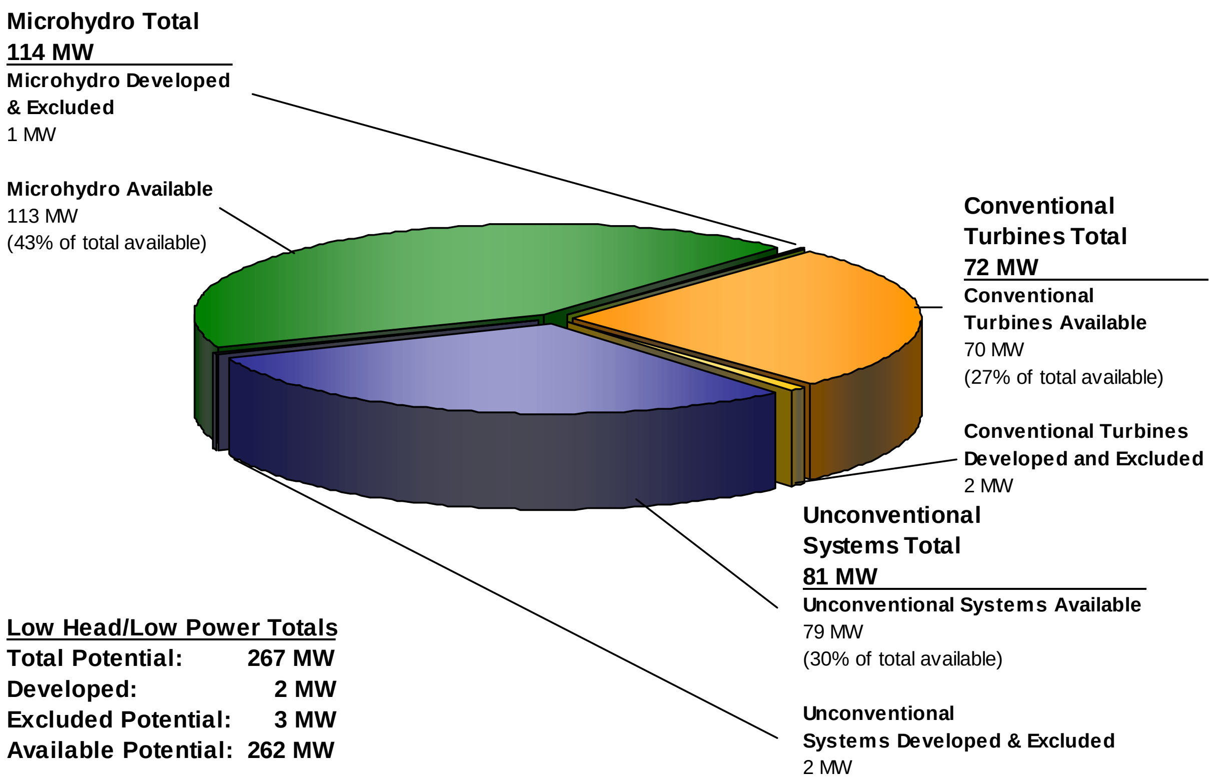
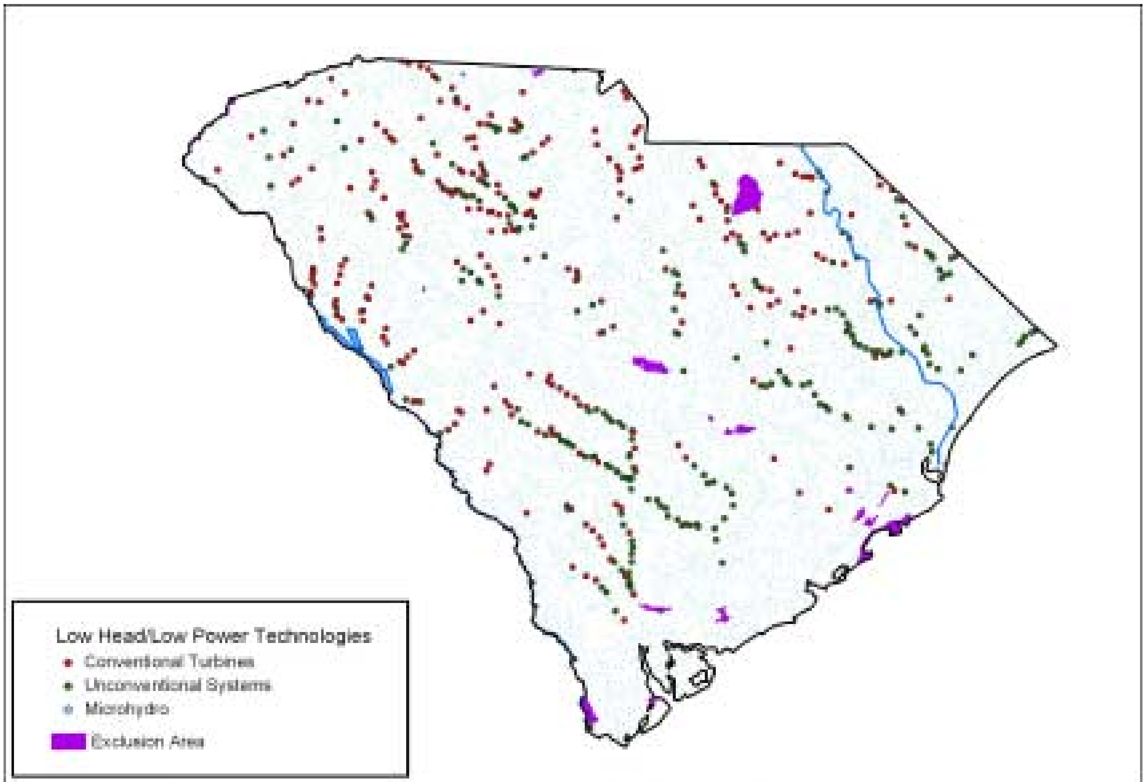


Figure B-189. Distribution of low head/low power hydropower potential in South Carolina among three low head/low power hydropower technology classes.



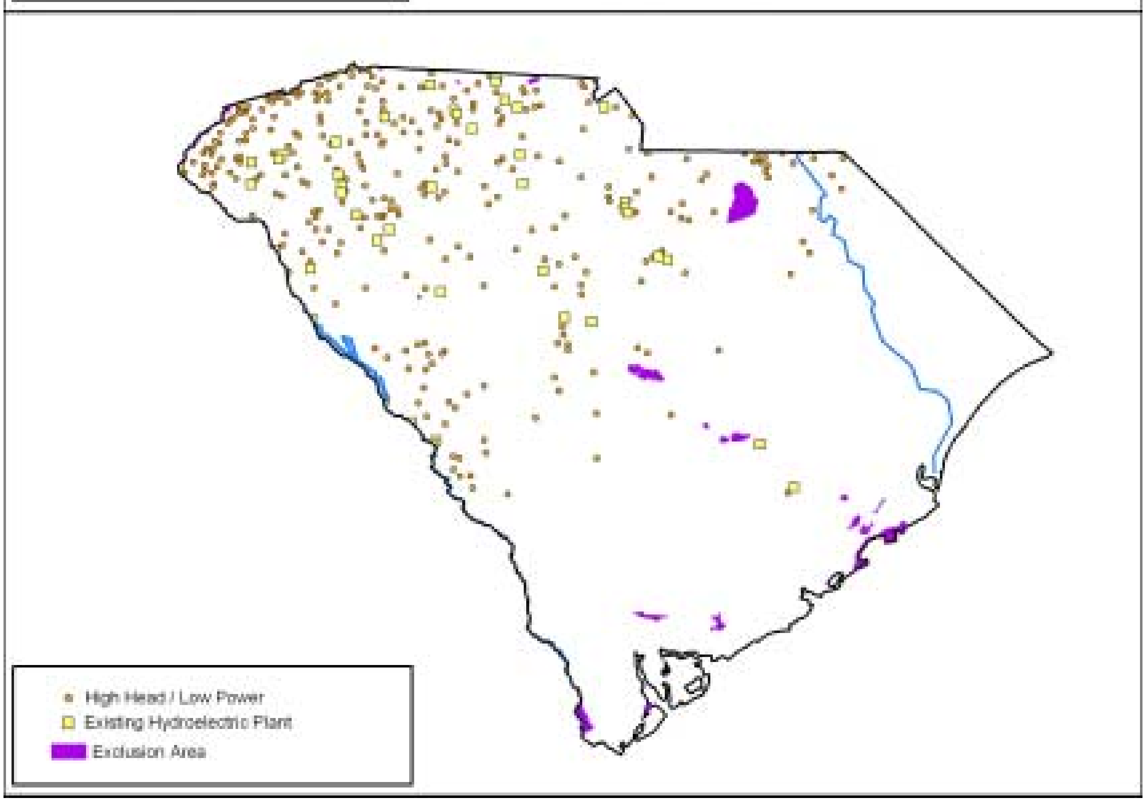


Figure B-190. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in South Carolina.

B.39 South Dakota

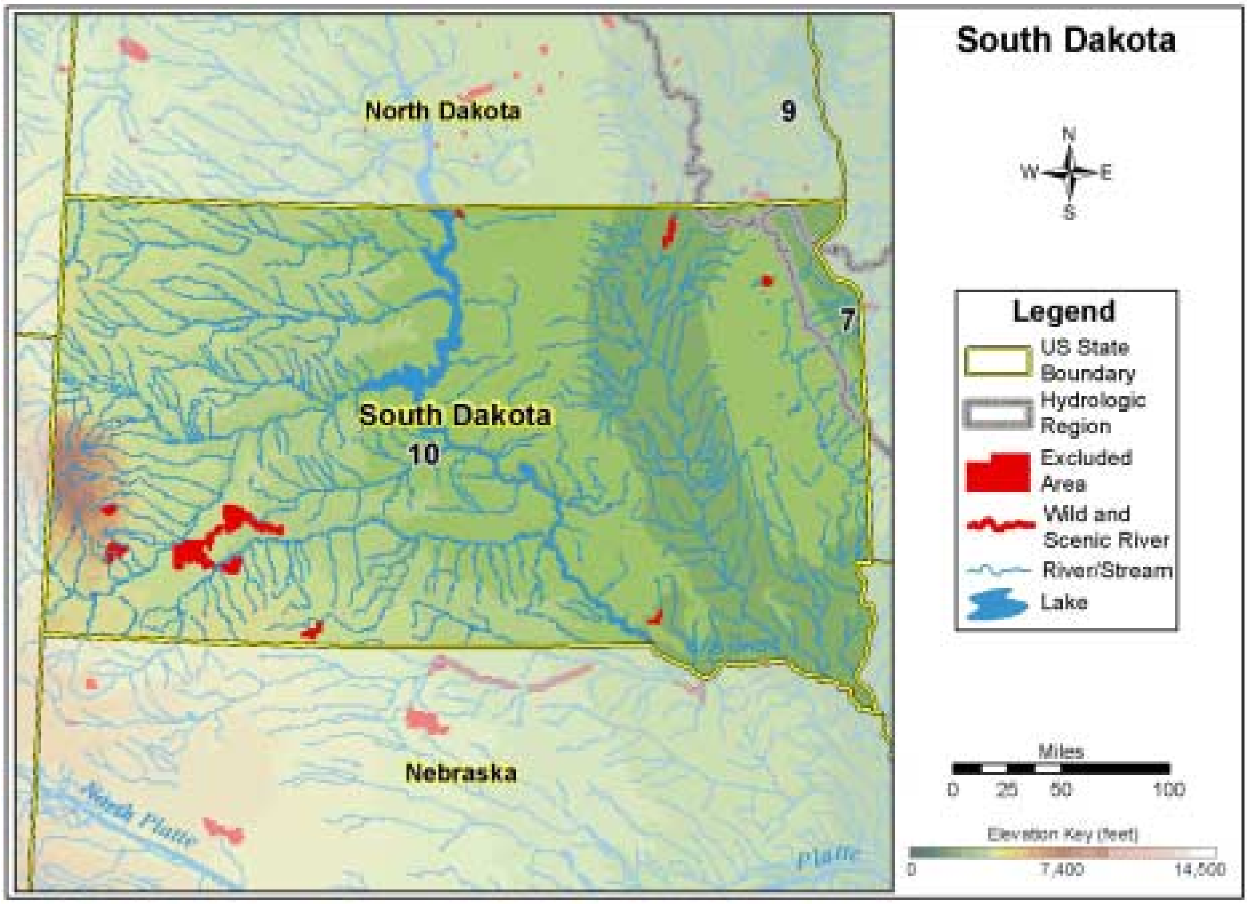


Figure B-191. South Dakota.

Table B-39. Summary of results of hydropower resource assessment of South Dakota.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	858	622	67	468
TOTAL HIGH POWER	423	622	58	42
High Head/High Power	323	622	—	—
Low Head/High Power	100	0	58	42
TOTAL LOW POWER	435	0	9	426
High Head/Low Power	105	0	3	102
Low Head/Low Power	330	0	6	324
Conventional Turbine	120	0	3	117
Unconventional Systems	33	0	1	32
Microhydro	177	0	2	175

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

Note: Excluded high head/high power potential was negative possibly due to overestimation of developed potential in excluded zones. The high head/high power excluded and available values are considered unreliable and are not included in the power class rollups. The total power and total high power available values are rolled up values that do not match the value obtained by horizontal summing of power category values.

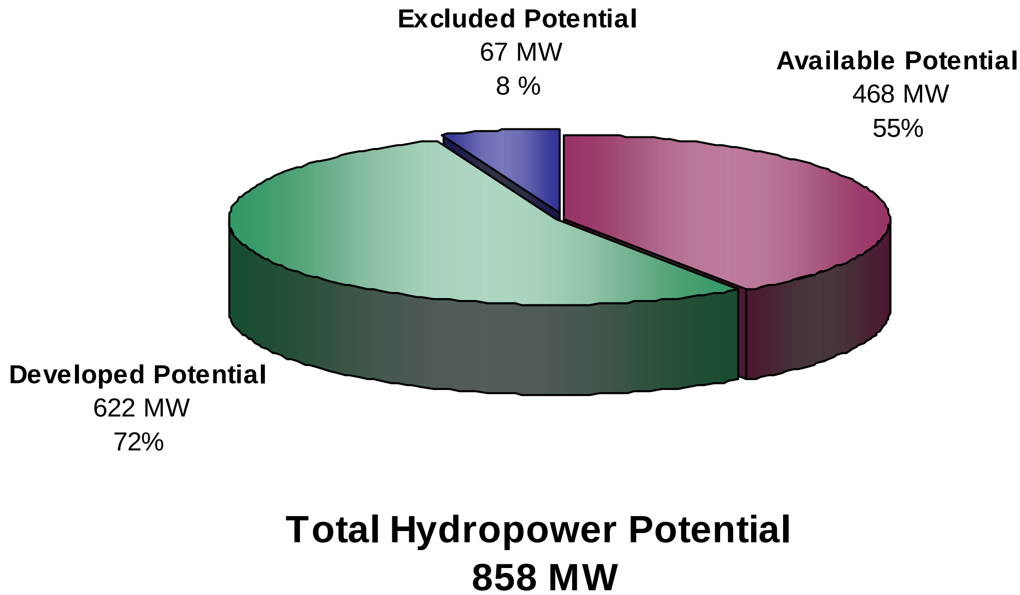


Figure B-192. Distribution of total hydropower potential in South Dakota.

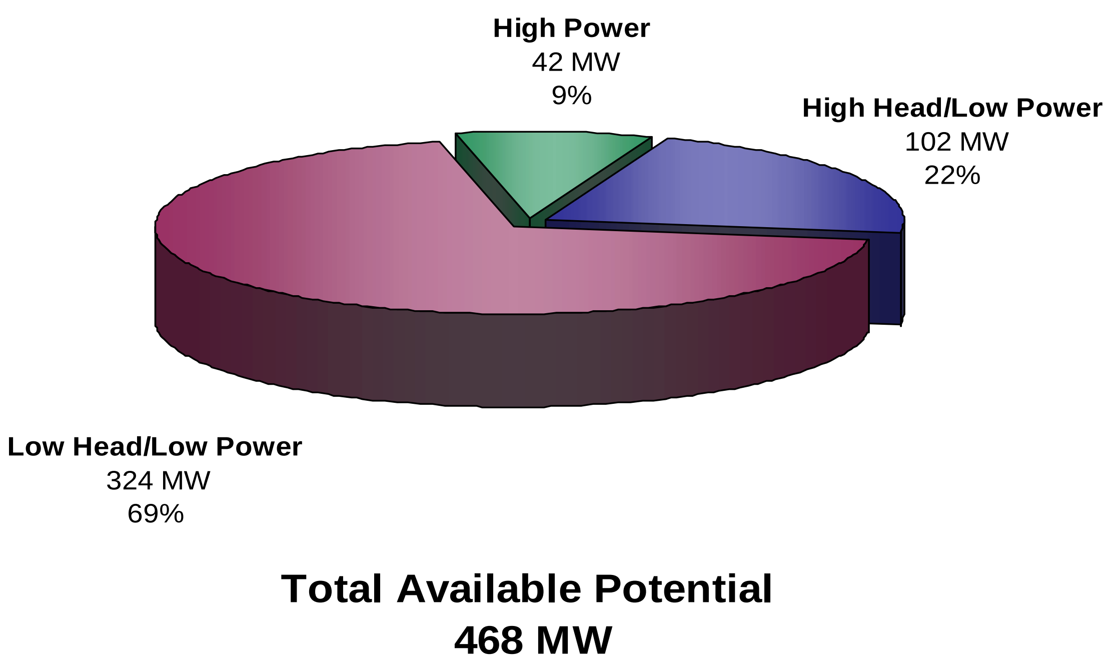


Figure B-193. Distribution of available hydropower potential in South Dakota.

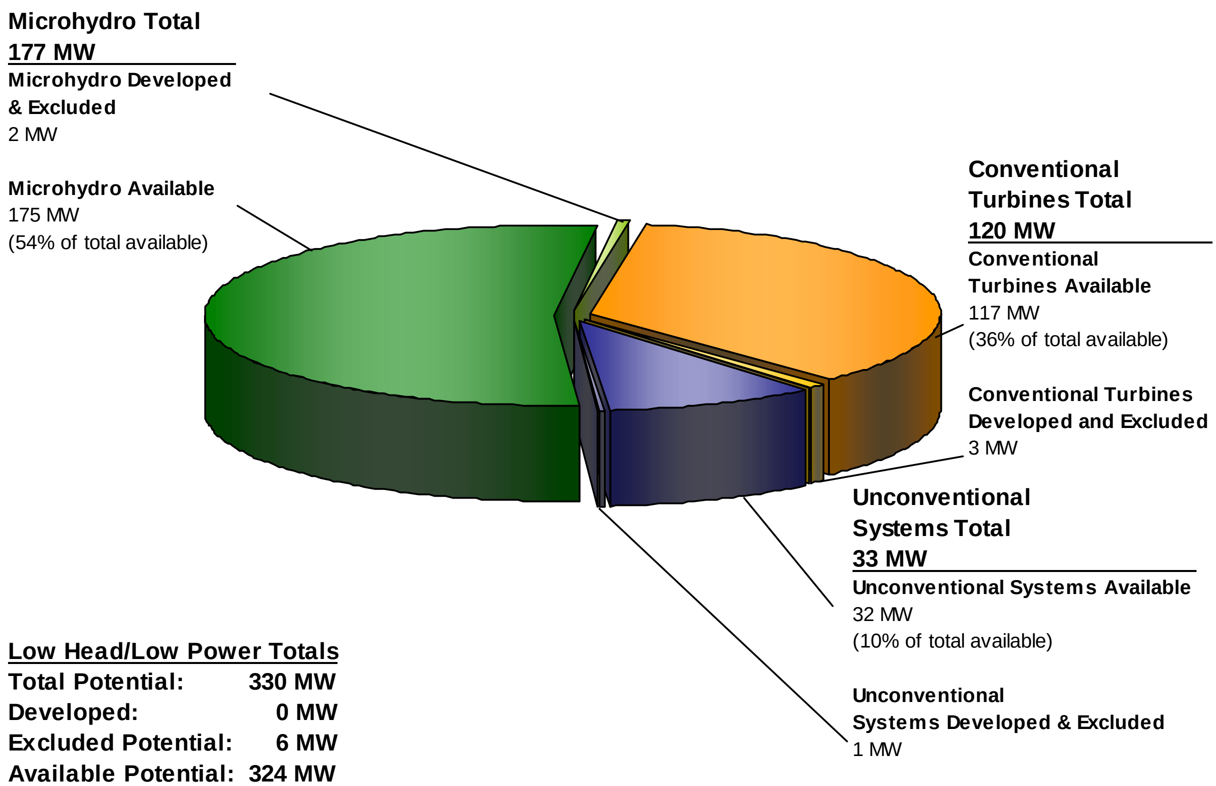


Figure B-194. Distribution of low head/low power hydropower potential in South Dakota among three low head/low power hydropower technology classes.

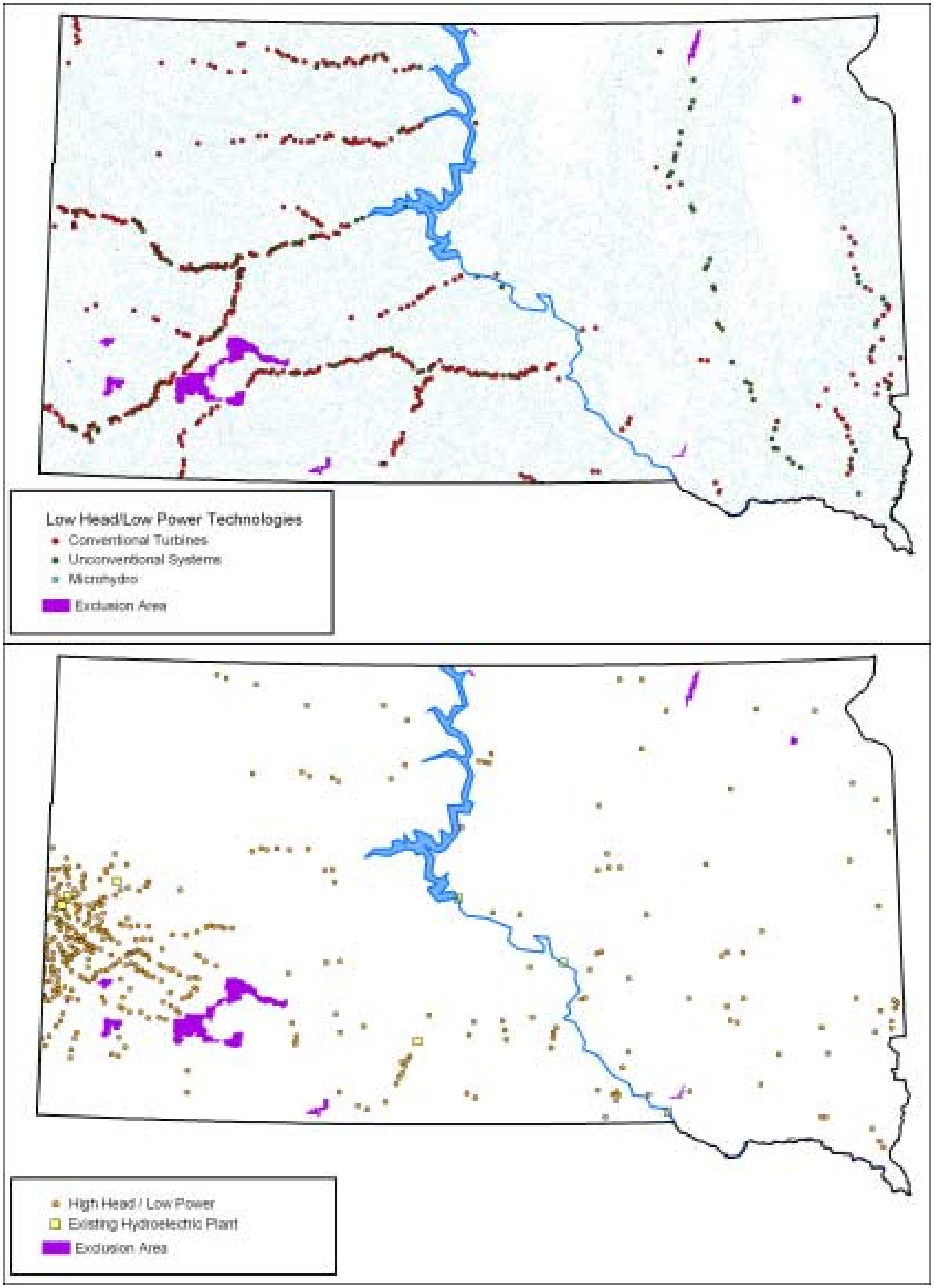


Figure B-195. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in South Dakota.

B.40 Tennessee

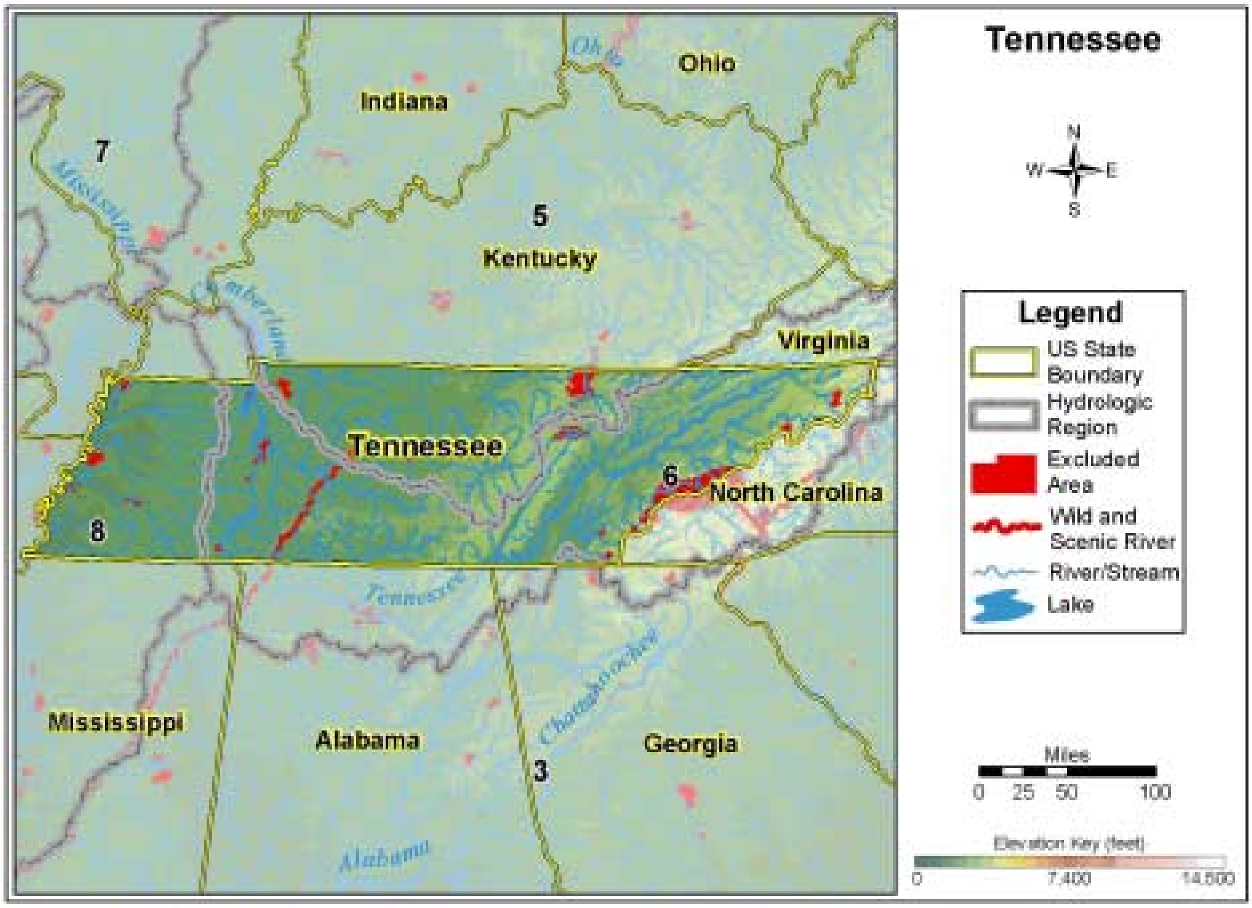


Figure B-196. Tennessee.

Table B-40. Summary of results of hydropower resource assessment of Tennessee.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**5,284**	**1,082**	**472**	**3,730**
TOTAL HIGH POWER	**4,368**	**1,082**	**386**	**2,900**
High Head/High Power	**1,606**	**1,061**	**278**	**267**
Low Head/High Power	**2,762**	**21**	**108**	**2,633**
TOTAL LOW POWER	**916**	**0**	**86**	**830**
High Head/Low Power	**463**	**0**	**66**	**397**
Low Head/Low Power	**453**	**0**	**20**	**433**
Conventional Turbine	151	0	6	145
Unconventional Systems	84	0	6	78
Microhydro	218	0	8	210

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

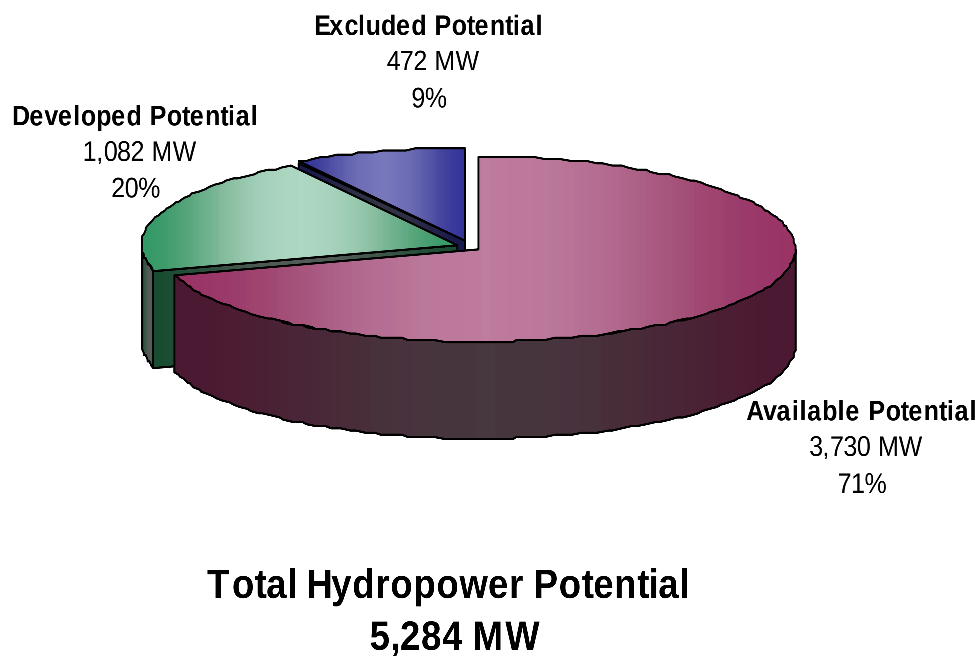


Figure B-197. Distribution of total hydropower potential in Tennessee.

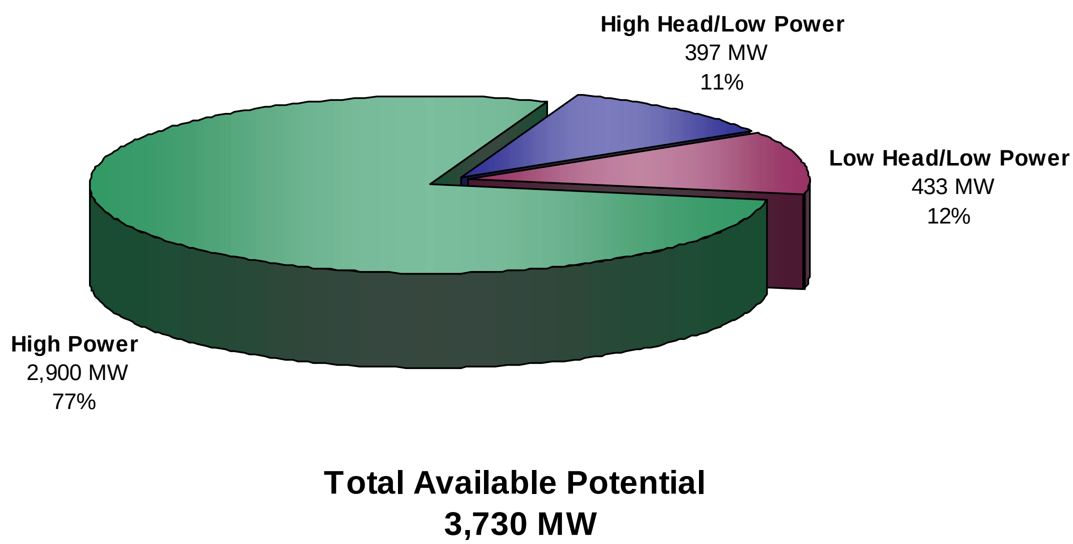


Figure B-198. Distribution of available hydropower potential in Tennessee.

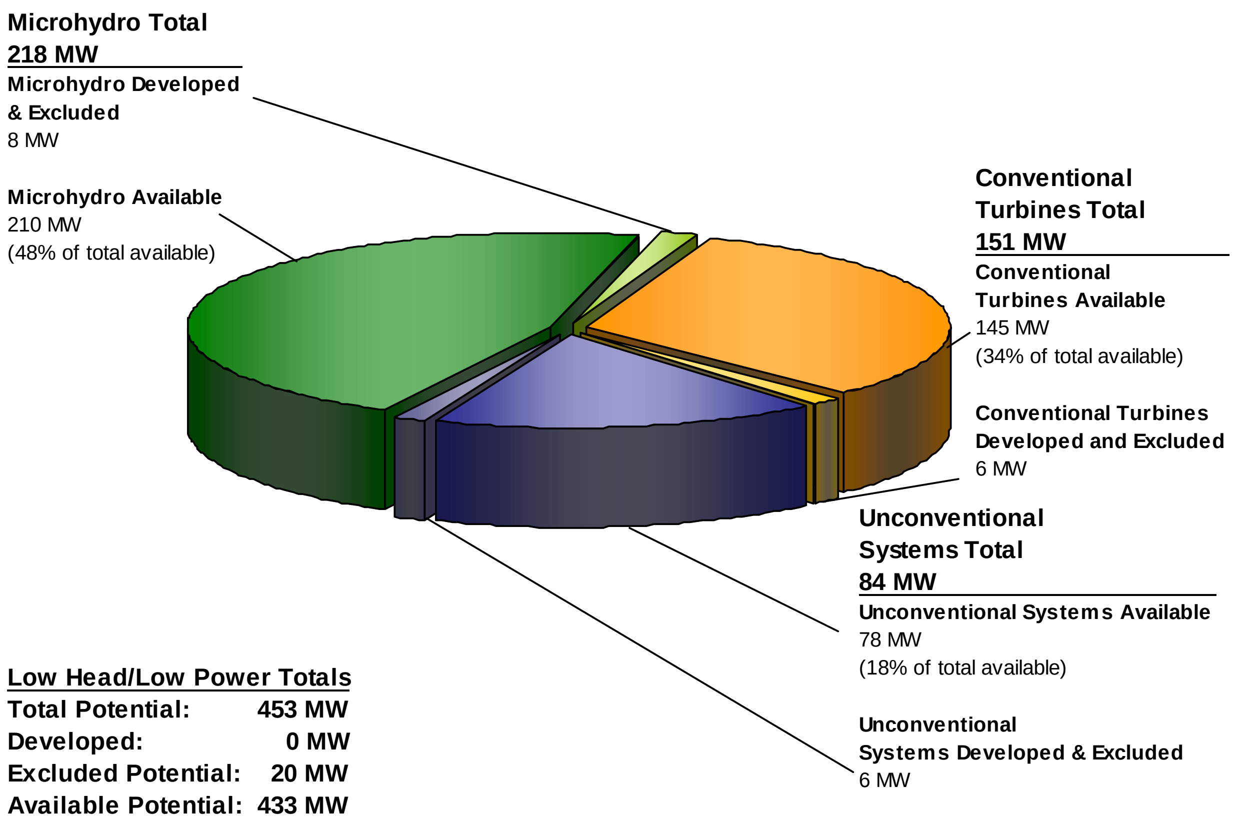


Figure B-199. Distribution of low head/low power hydropower potential in Tennessee among three low head/low power hydropower technology classes.

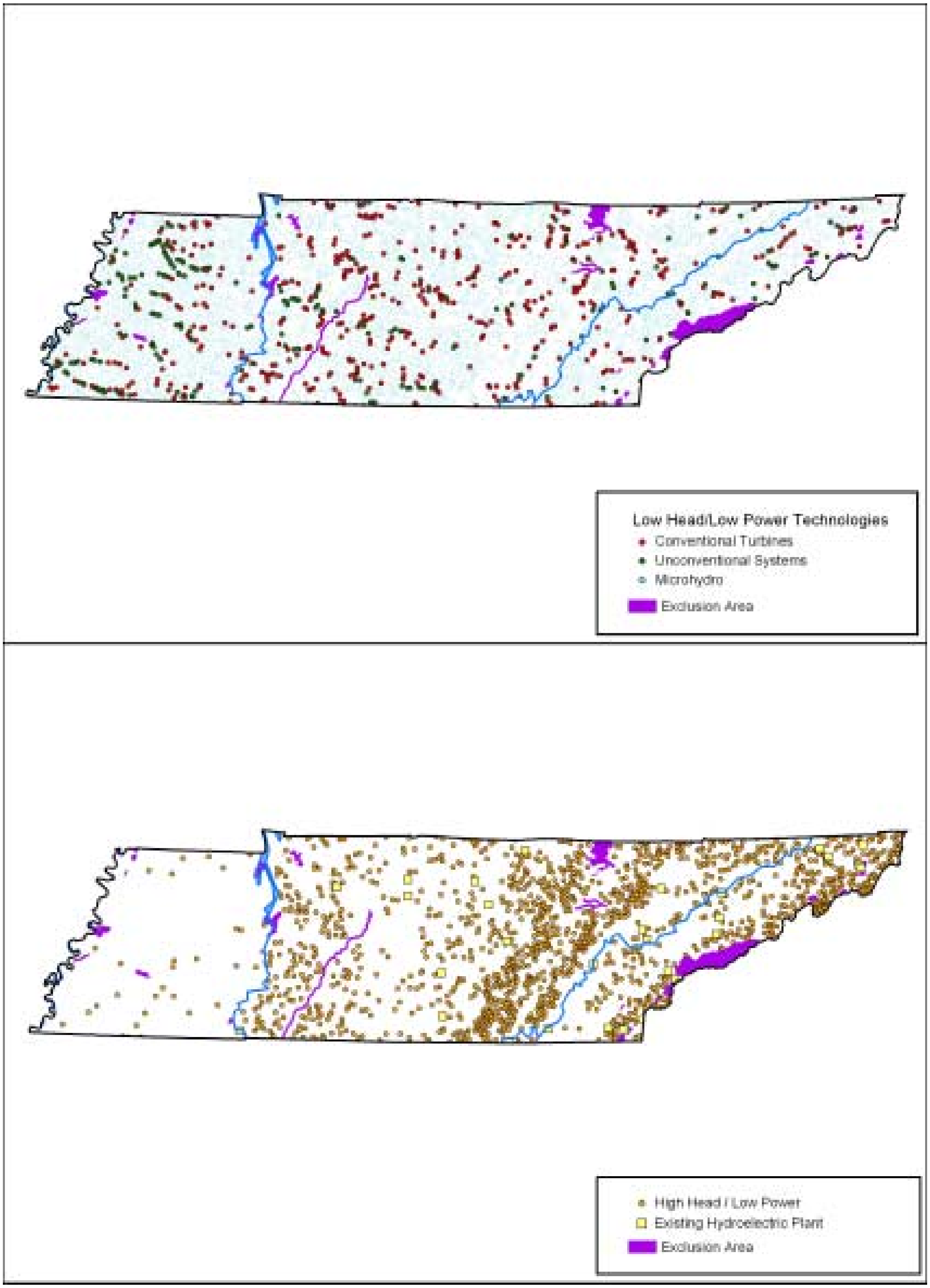


Figure B-200. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Tennessee.

B.41 Texas

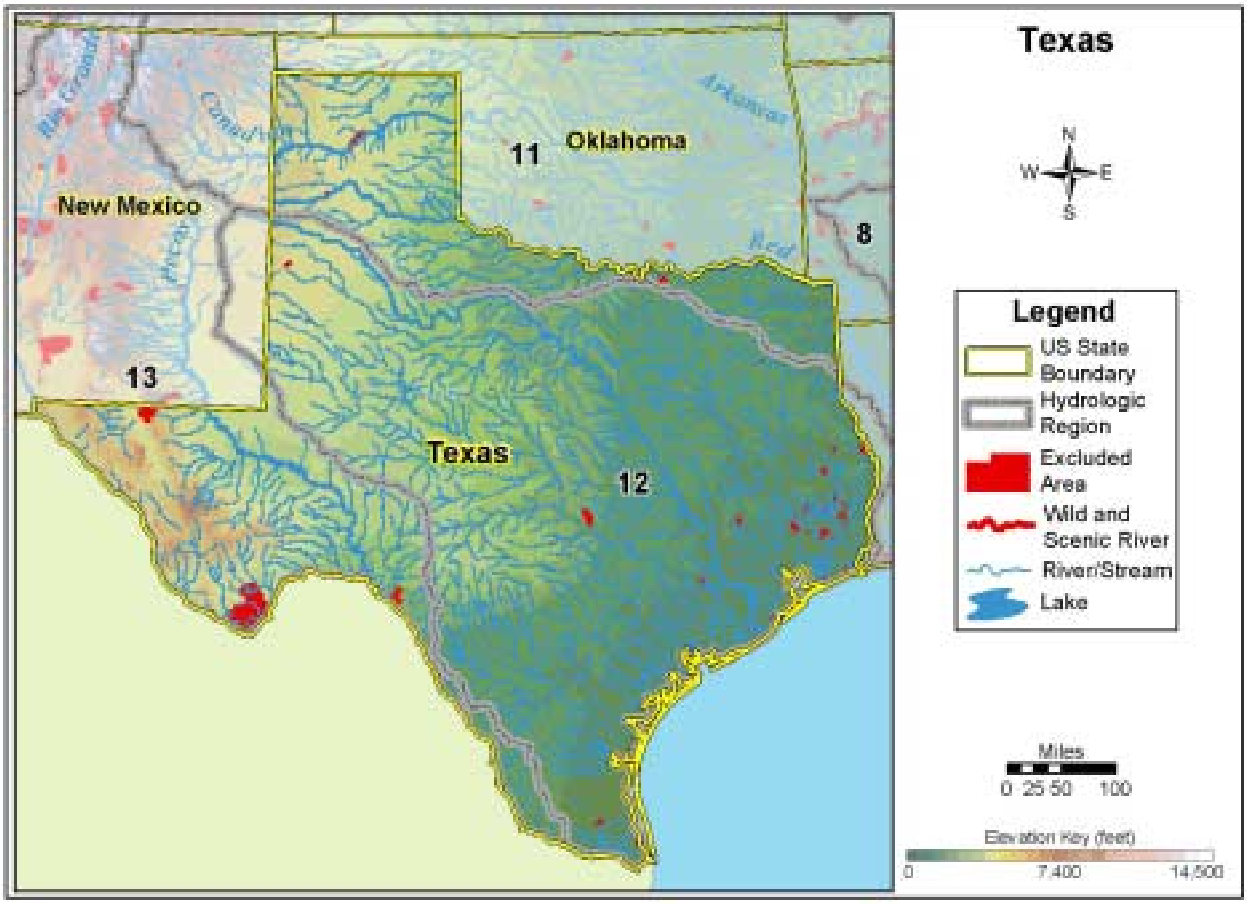


Figure B-201. Texas.

Table B-41. Summary of results of hydropower resource assessment of Texas.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**2,336**	**189**	**119**	**2,028**
TOTAL HIGH POWER	**627**	**189**	**83**	**355**
High Head/High Power	**273**	**179**	**33**	**61**
Low Head/High Power	**354**	**10**	**50**	**294**
TOTAL LOW POWER	**1,709**	**0**	**36**	**1,673**
High Head/Low Power	**248**	**0**	**5**	**243**
Low Head/Low Power	**1,461**	**0**	**31**	**1,430**
Conventional Turbine	452	0	9	443
Unconventional Systems	253	0	11	242
Microhydro	756	0	11	745

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

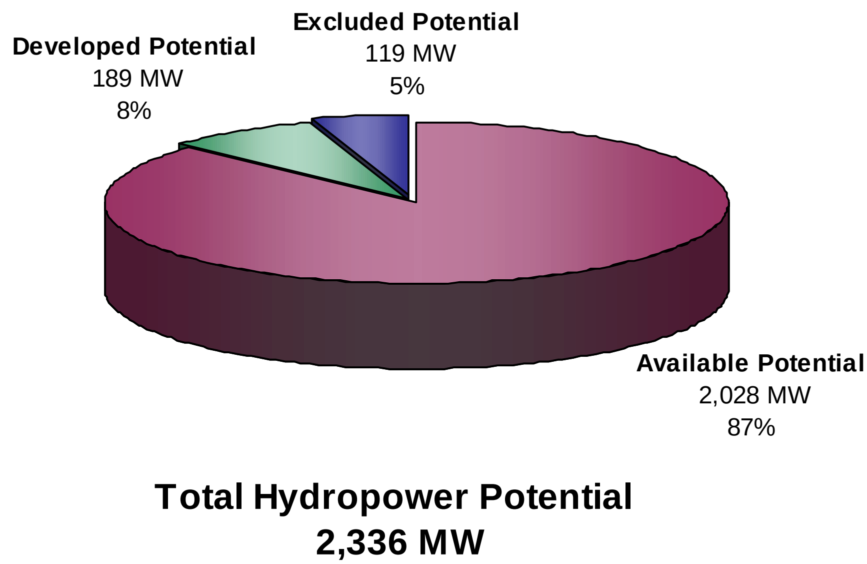


Figure B-202. Distribution of total hydropower potential in Texas.

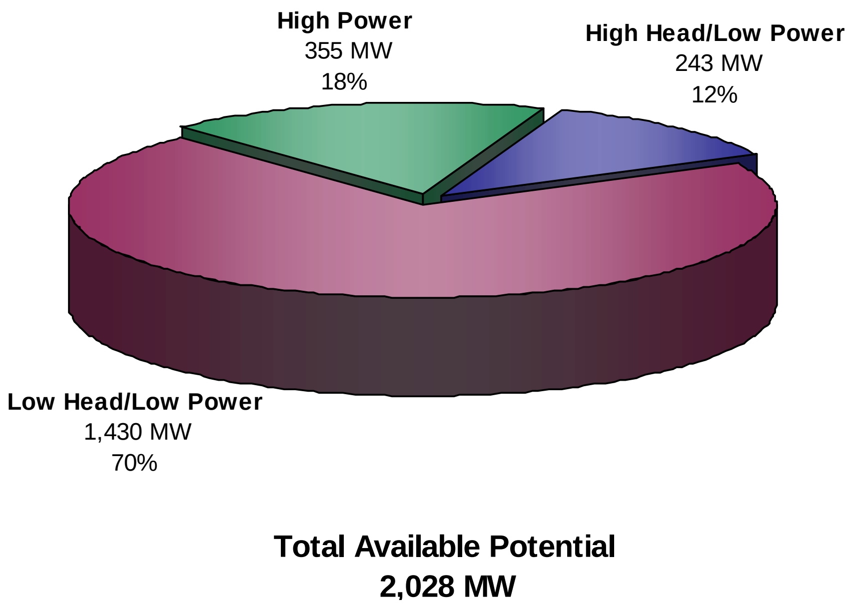


Figure B-203. Distribution of available hydropower potential in Texas.

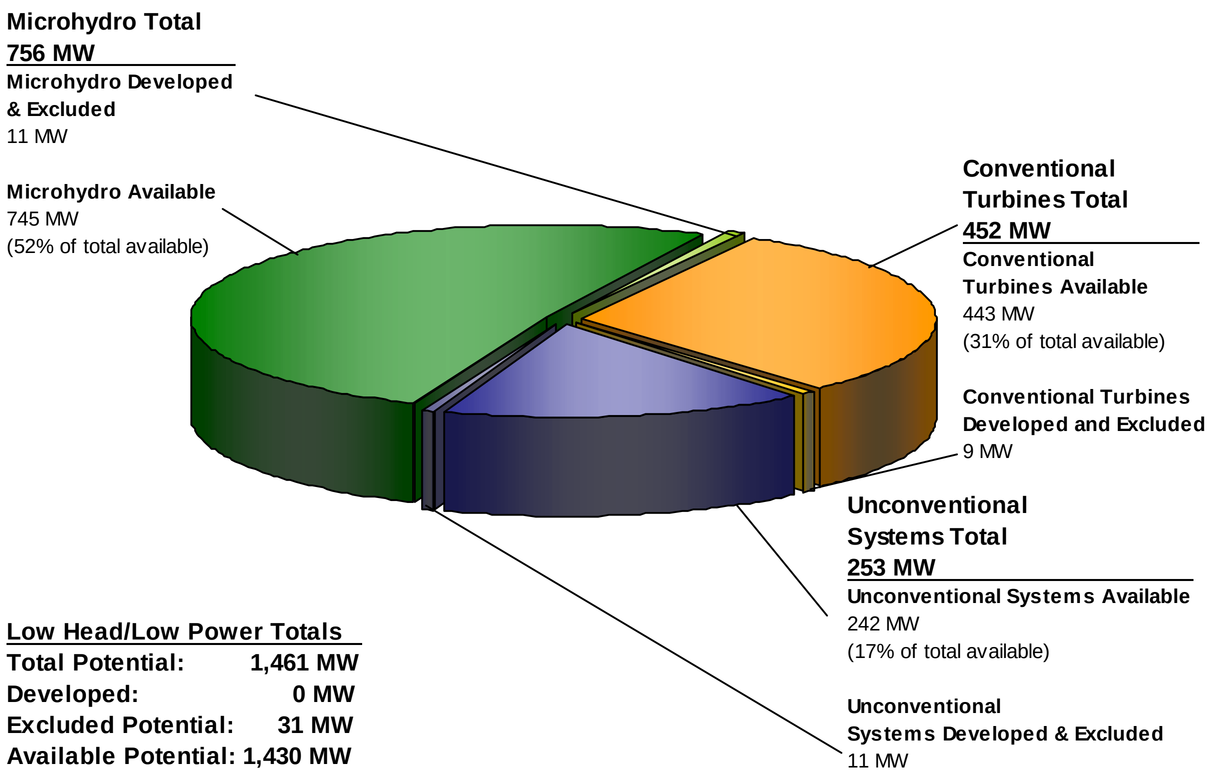


Figure B-204. Distribution of low head/low power hydropower potential in Texas among three low head/low power hydropower technology classes.

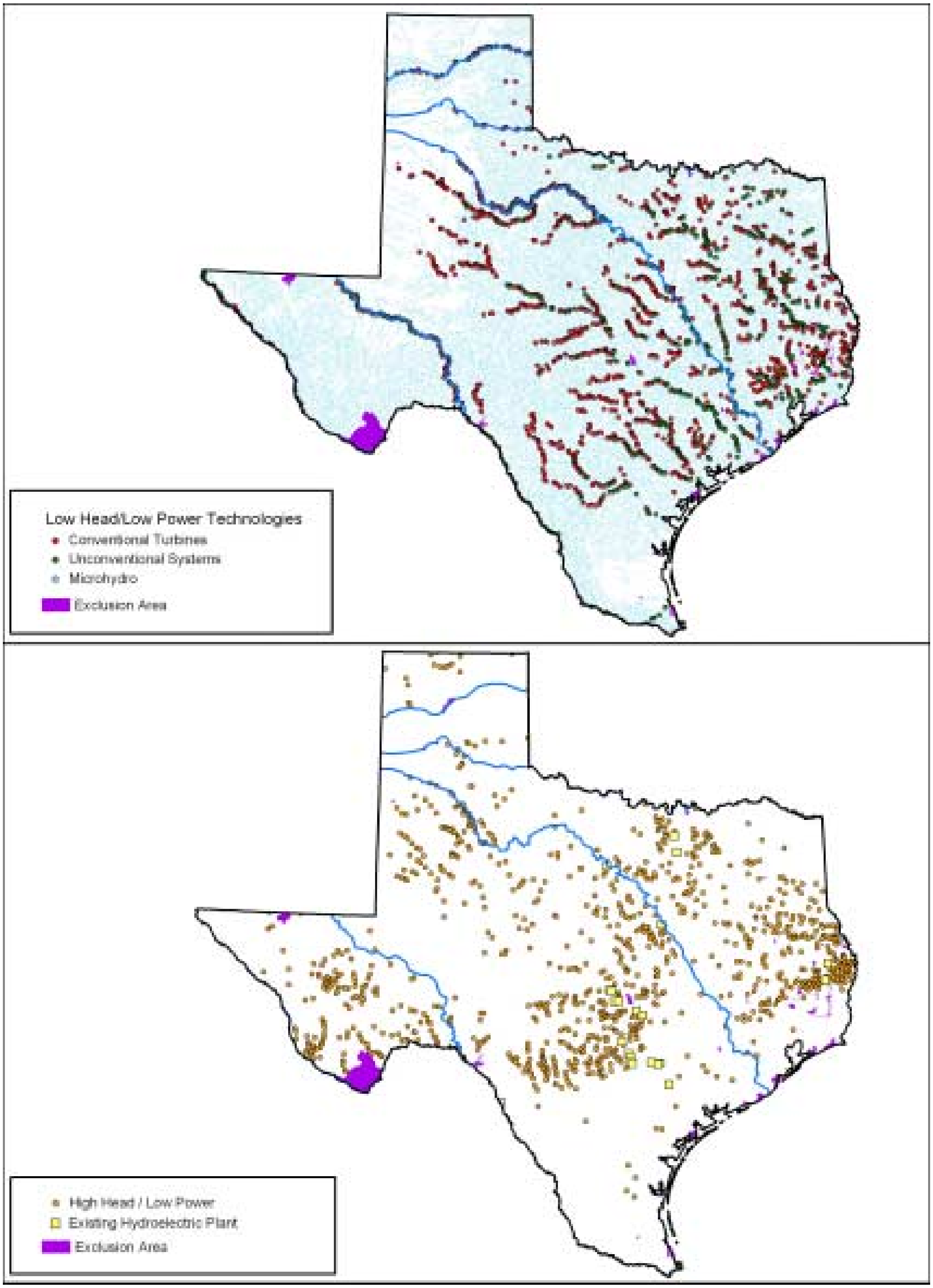


Figure B-205. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Texas.

B.42 Utah

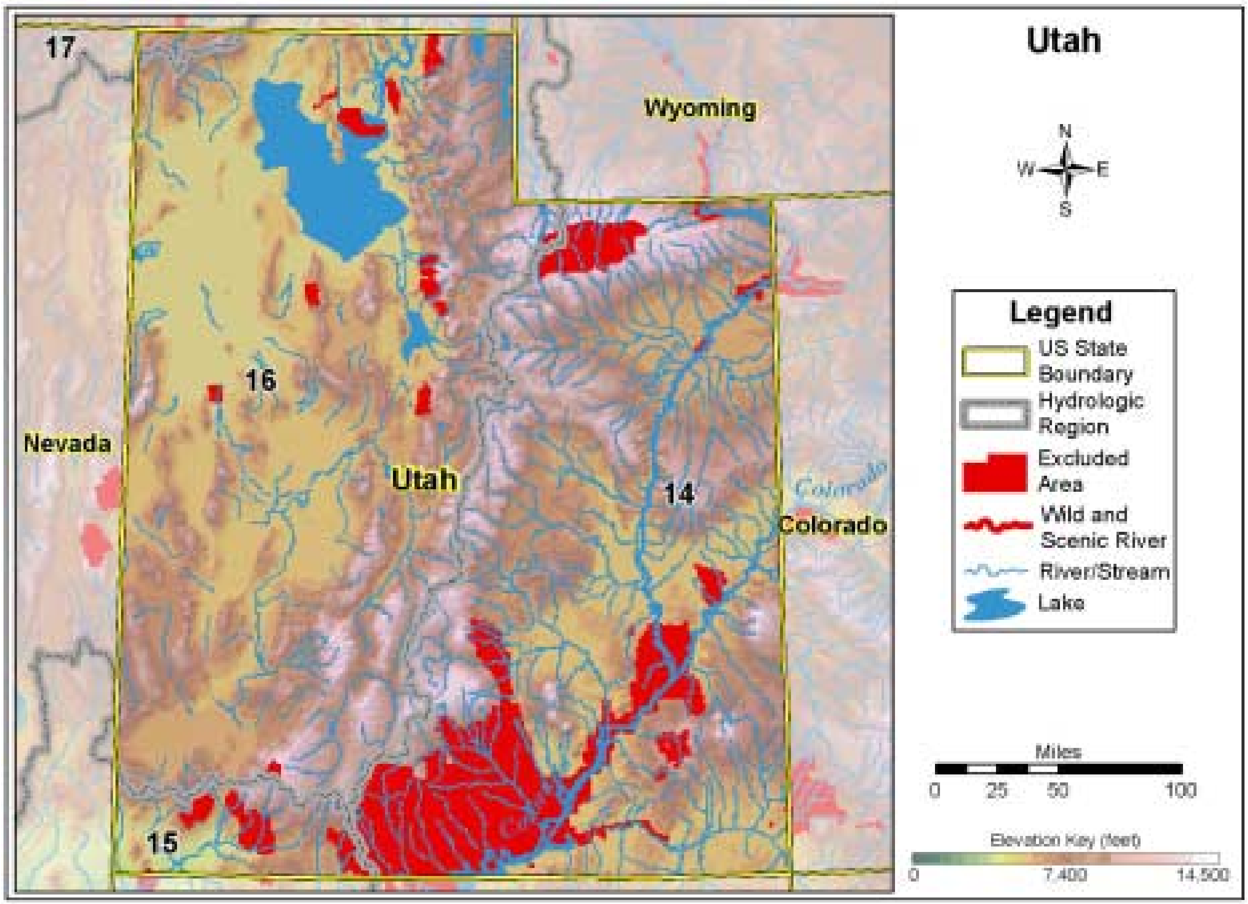


Figure B-206. Utah.

Table B-42. Summary of results of hydropower resource assessment of Utah.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**3,924**	**135**	**933**	**2,856**
TOTAL HIGH POWER	**2,385**	**124**	**755**	**1,506**
High Head/High Power	**1,777**	**124**	**556**	**1,097**
Low Head/High Power	**608**	**0**	**199**	**409**
TOTAL LOW POWER	**1,539**	**11**	**178**	**1,350**
High Head/Low Power	**1,126**	**10**	**139**	**977**
Low Head/Low Power	**413**	**1**	**39**	**373**
Conventional Turbine	92	1	4	87
Unconventional Systems	37	0	5	32
Microhydro	284	0	30	254

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

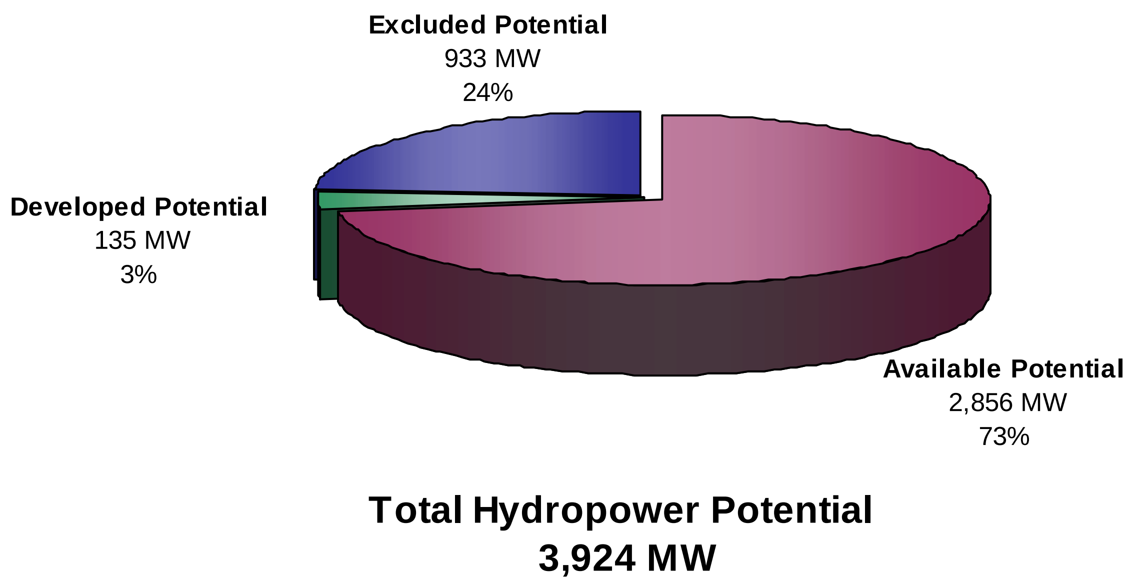


Figure B-207. Distribution of total hydropower potential in Utah.

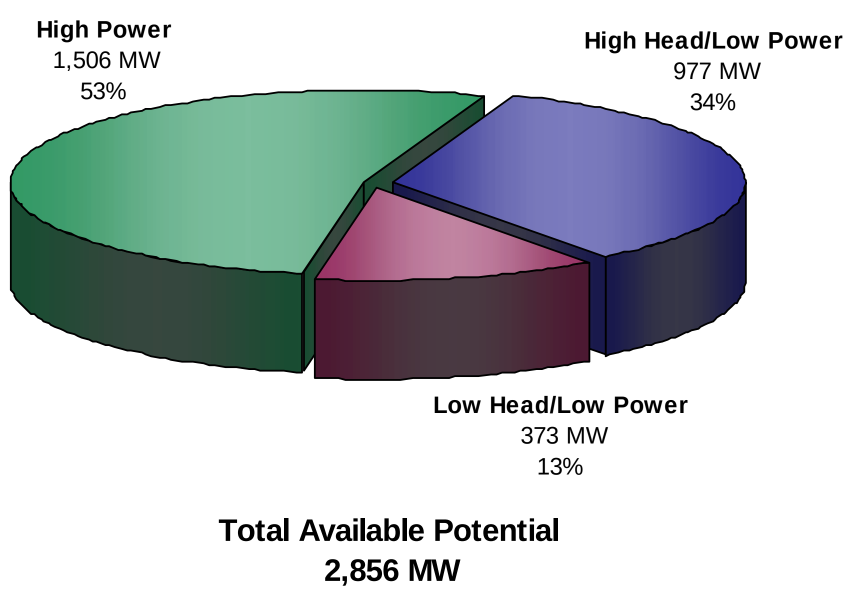


Figure B-208. Distribution of available hydropower potential in Utah.

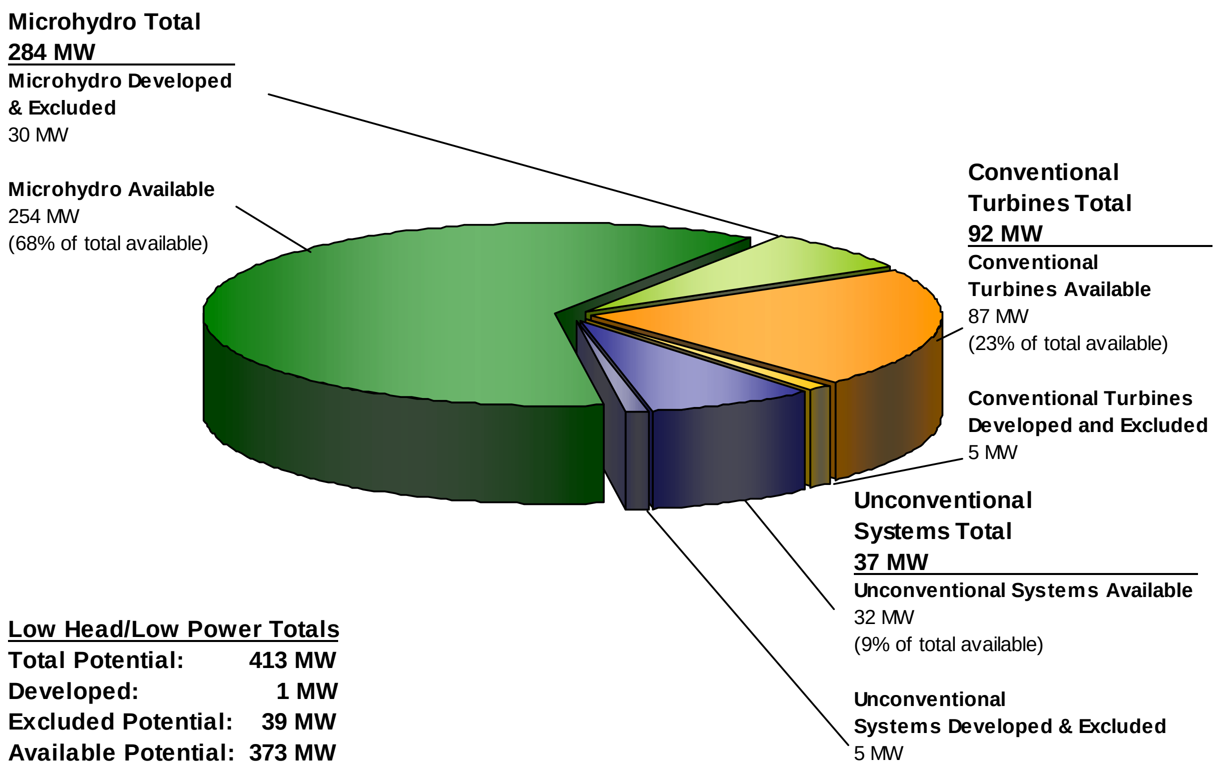


Figure B-209. Distribution of low head/low power hydropower potential in Utah among three low head/low power hydropower technology classes.

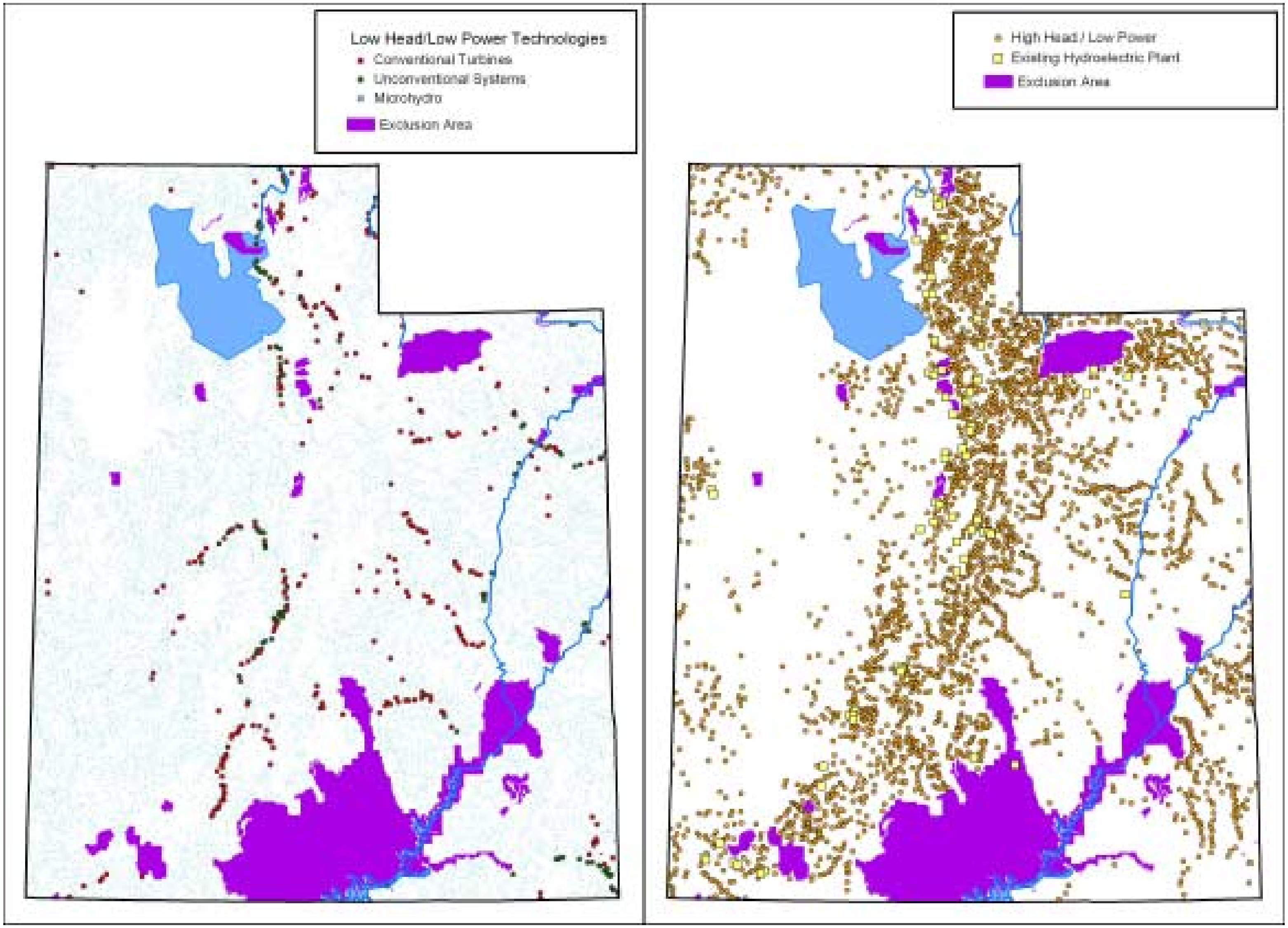


Figure B-210. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Utah.

B.43 Vermont

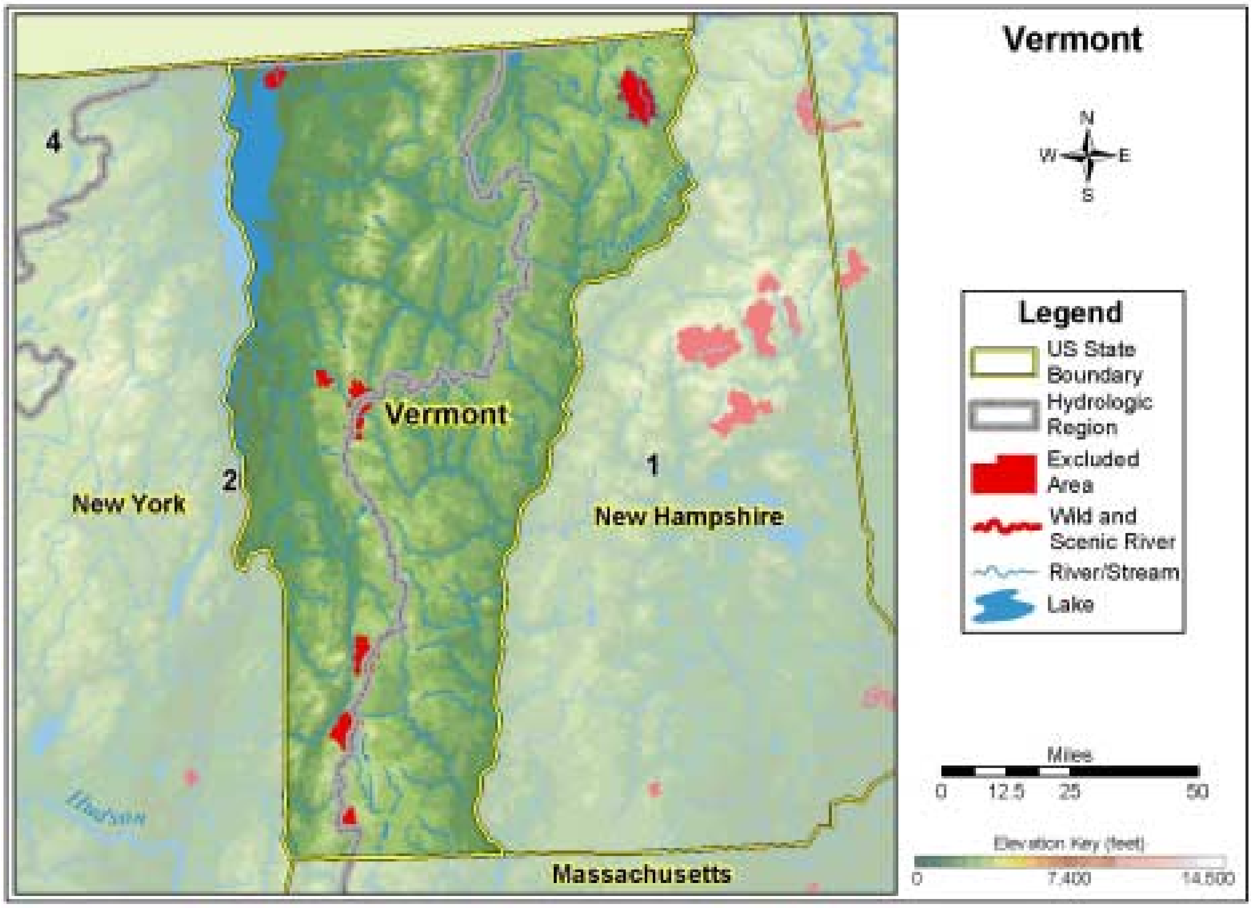


Figure B-211. Vermont.

Table B-43. Summary of results of hydropower resource assessment of Vermont.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,144**	**127**	**49**	**968**
TOTAL HIGH POWER	**682**	**121**	**34**	**527**
High Head/High Power	**533**	**117**	**33**	**383**
Low Head/High Power	**149**	**4**	**1**	**144**
TOTAL LOW POWER	**462**	**6**	**15**	**441**
High Head/Low Power	**372**	**3**	**14**	**355**
Low Head/Low Power	**90**	**3**	**1**	**86**
Conventional Turbine	40	3	0	37
Unconventional Systems	15	0	0	15
Microhydro	35	0	1	34

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

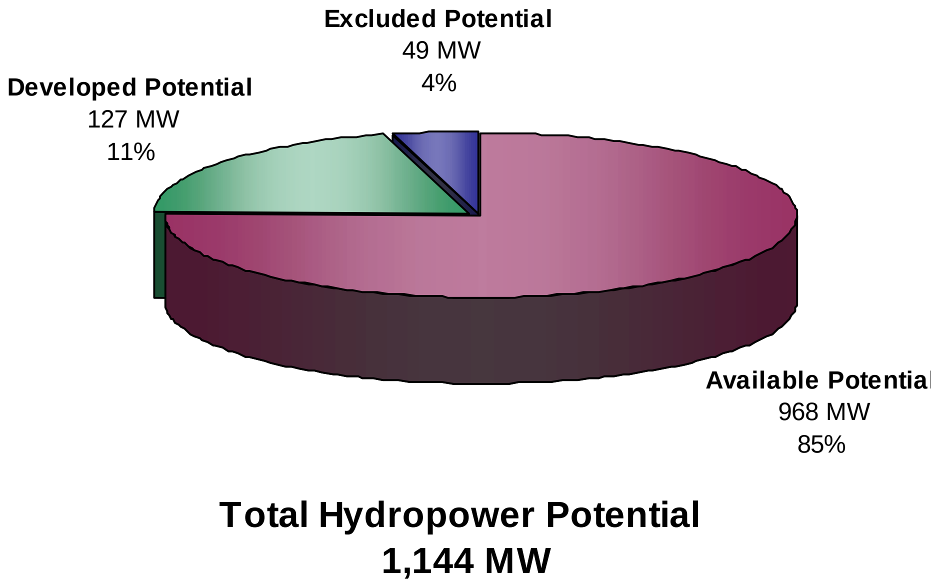


Figure B-212. Distribution of total hydropower potential in Vermont.

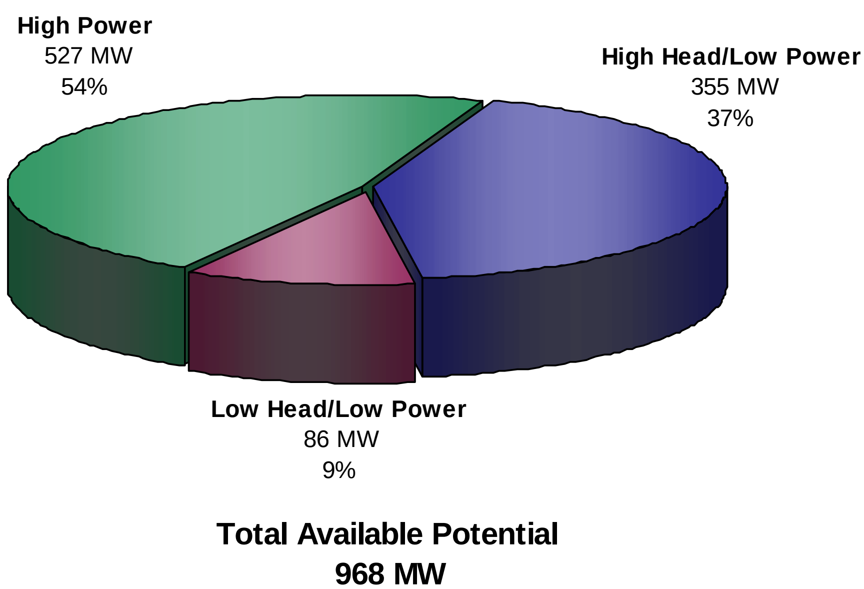


Figure B-213. Distribution of available hydropower potential in Vermont.

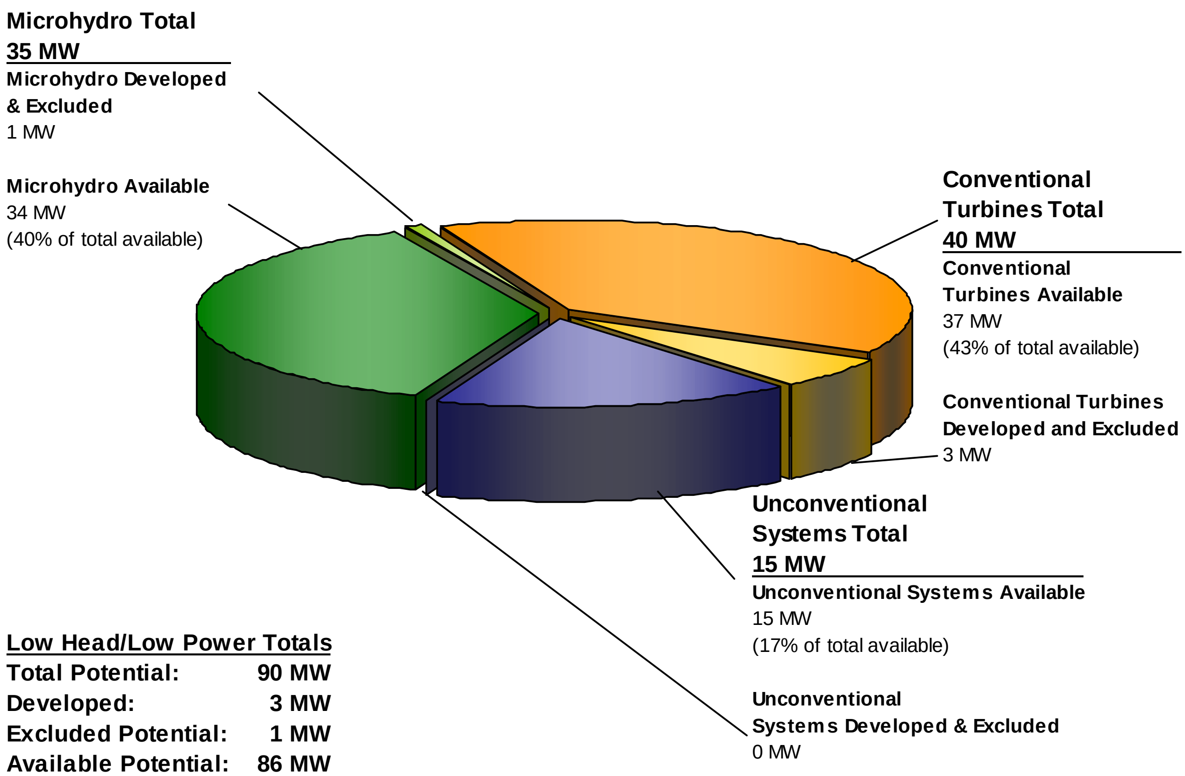


Figure B-214. Distribution of low head/low power hydropower potential in Vermont among three low head/low power hydropower technology classes.

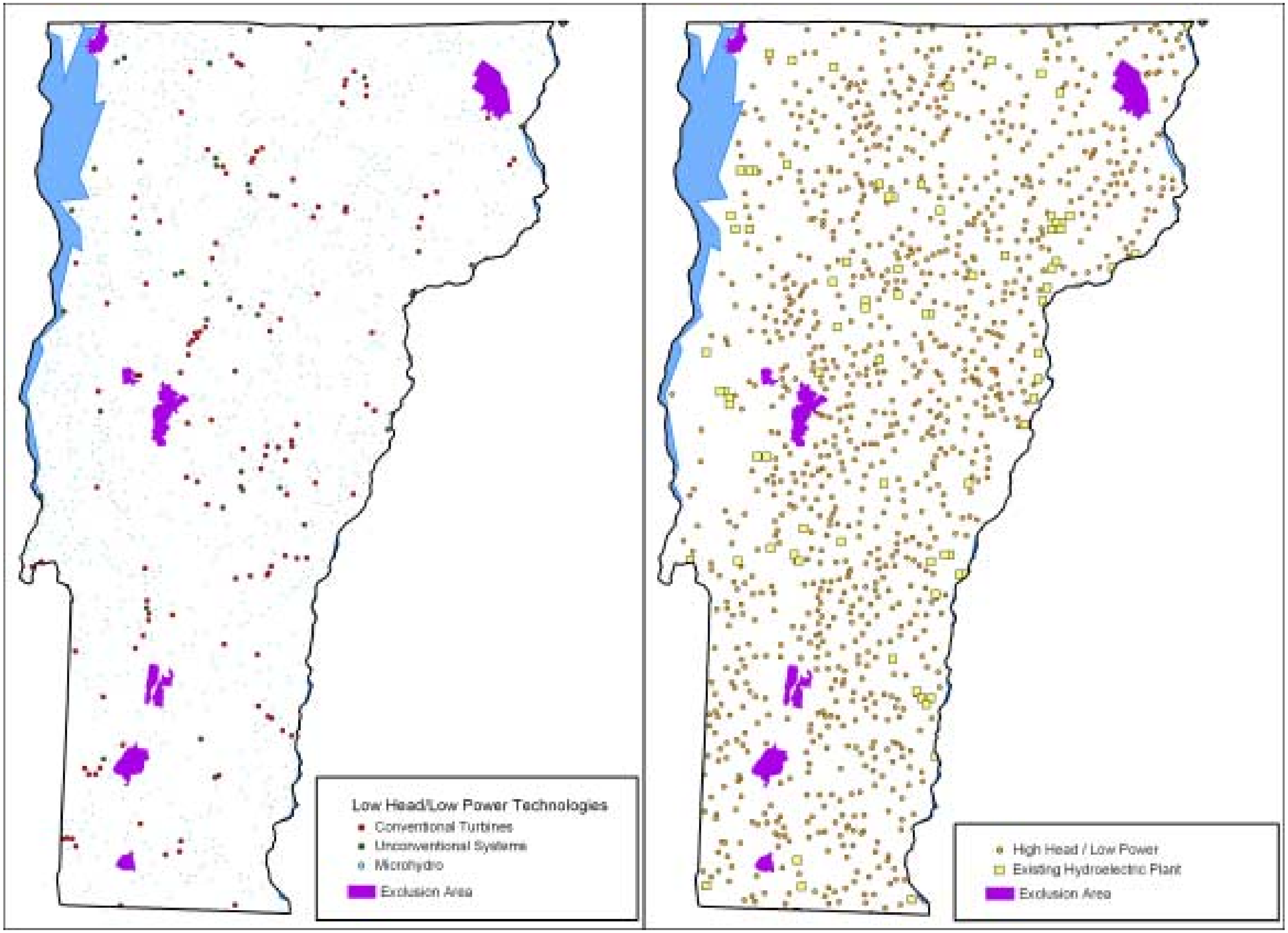


Figure B-215. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Vermont.

B.44 Virginia

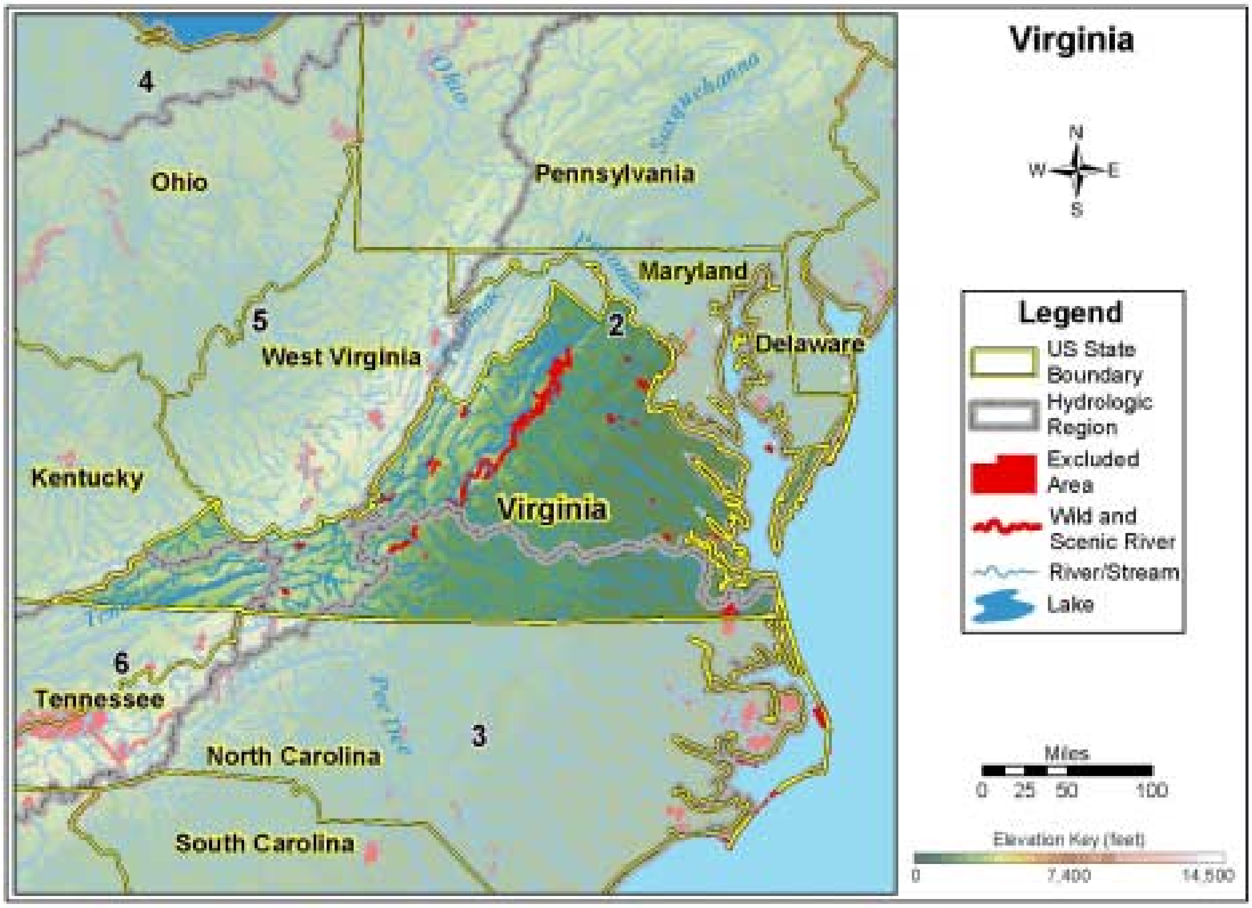


Figure B-216. Virginia.

Table B-44. Summary of results of hydropower resource assessment of Virginia.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**2,220**	**147**	**194**	**1,879**
TOTAL HIGH POWER	**1,375**	**143**	**118**	**1,114**
High Head/High Power	**847**	**133**	**65**	**649**
Low Head/High Power	**528**	**10**	**53**	**465**
TOTAL LOW POWER	**845**	**4**	**76**	**765**
High Head/Low Power	**478**	**1**	**64**	**413**
Low Head/Low Power	**367**	**3**	**12**	**352**
Conventional Turbine	135	3	2	130
Unconventional Systems	50	0	1	49
Microhydro	182	0	9	173

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

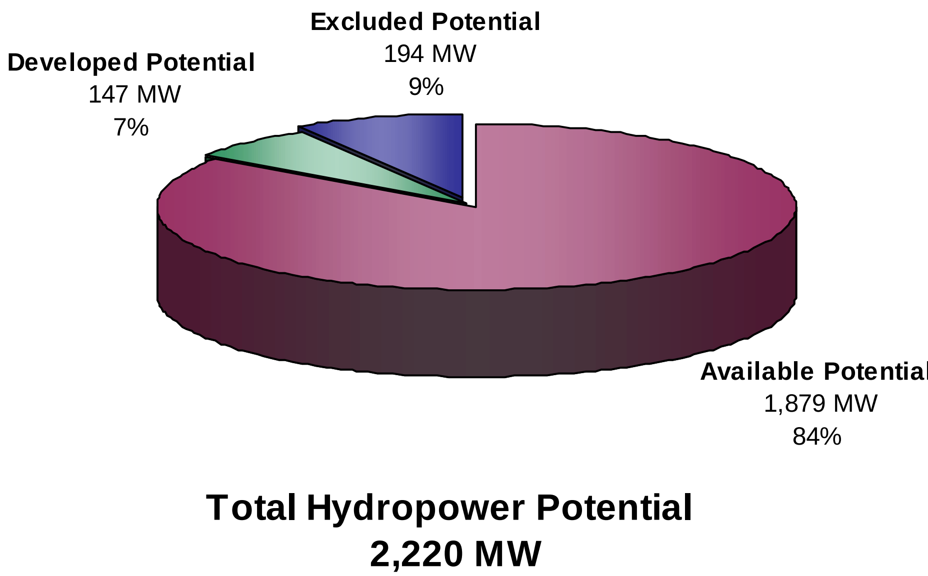


Figure B-217. Distribution of total hydropower potential in Virginia.

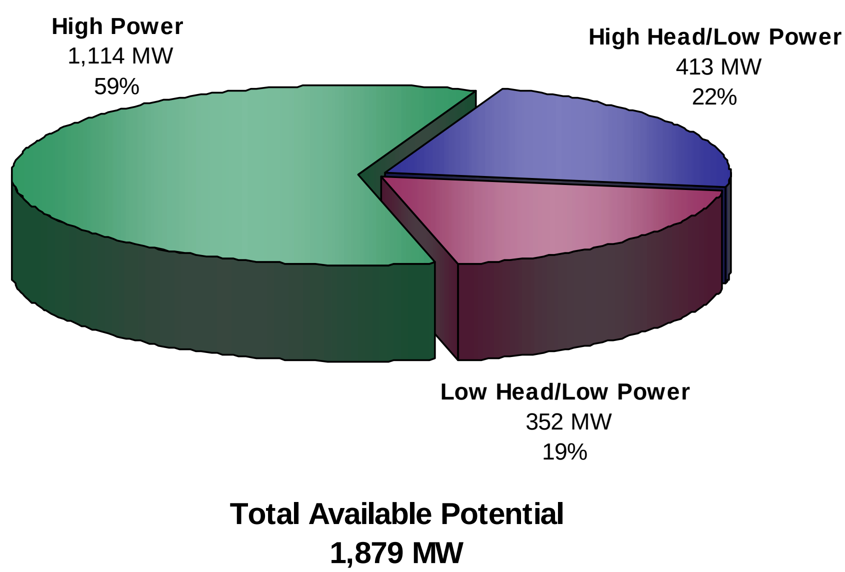


Figure B-218. Distribution of available hydropower potential in Virginia.

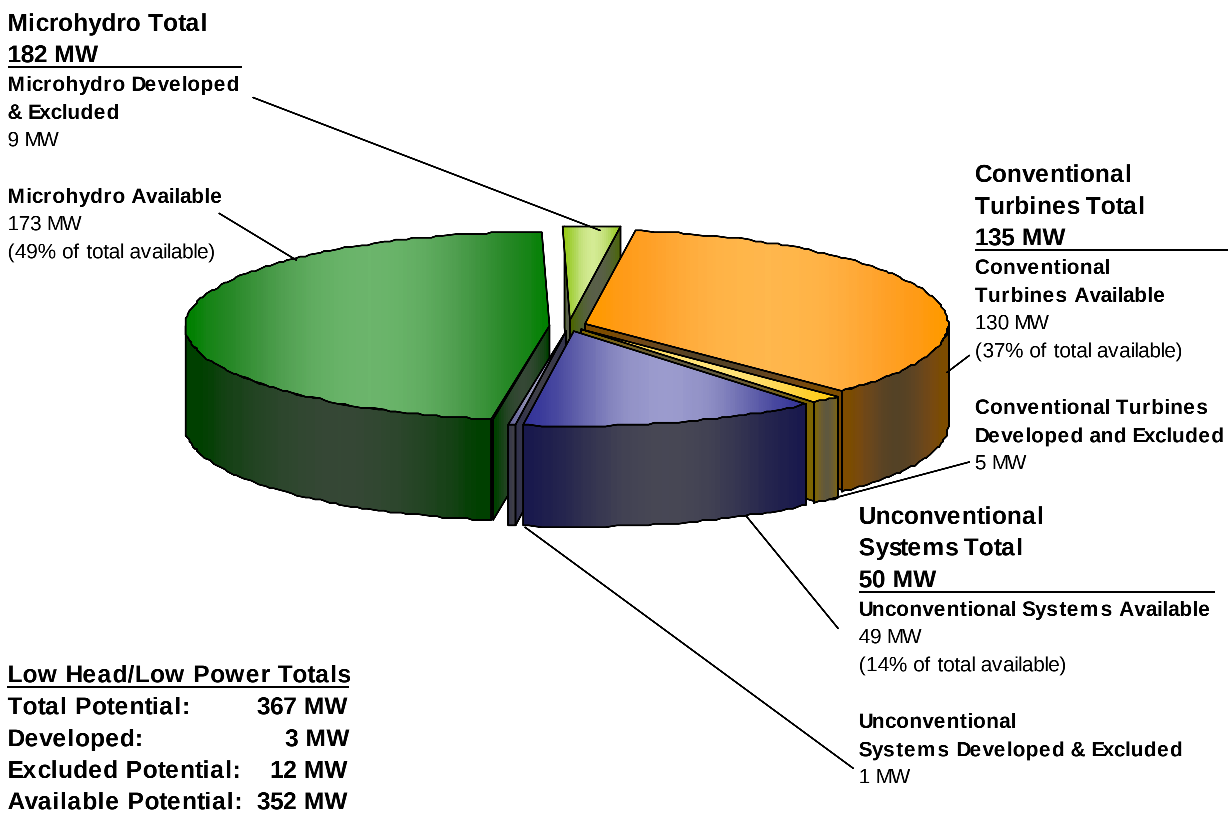


Figure B-219. Distribution of low head/low power hydropower potential in Virginia among three low head/low power hydropower technology classes.

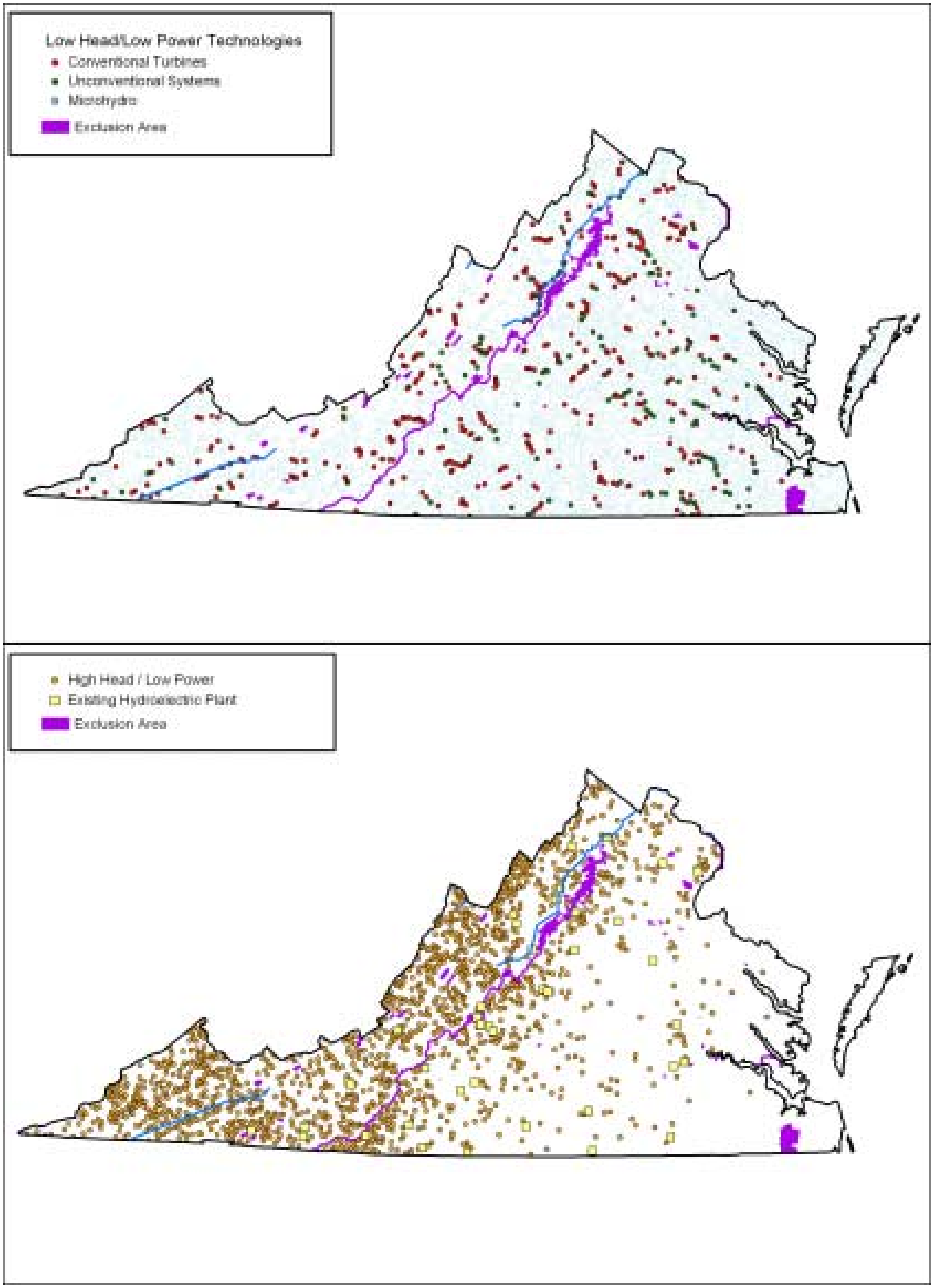


Figure B-220. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Virginia.

B.45 Washington

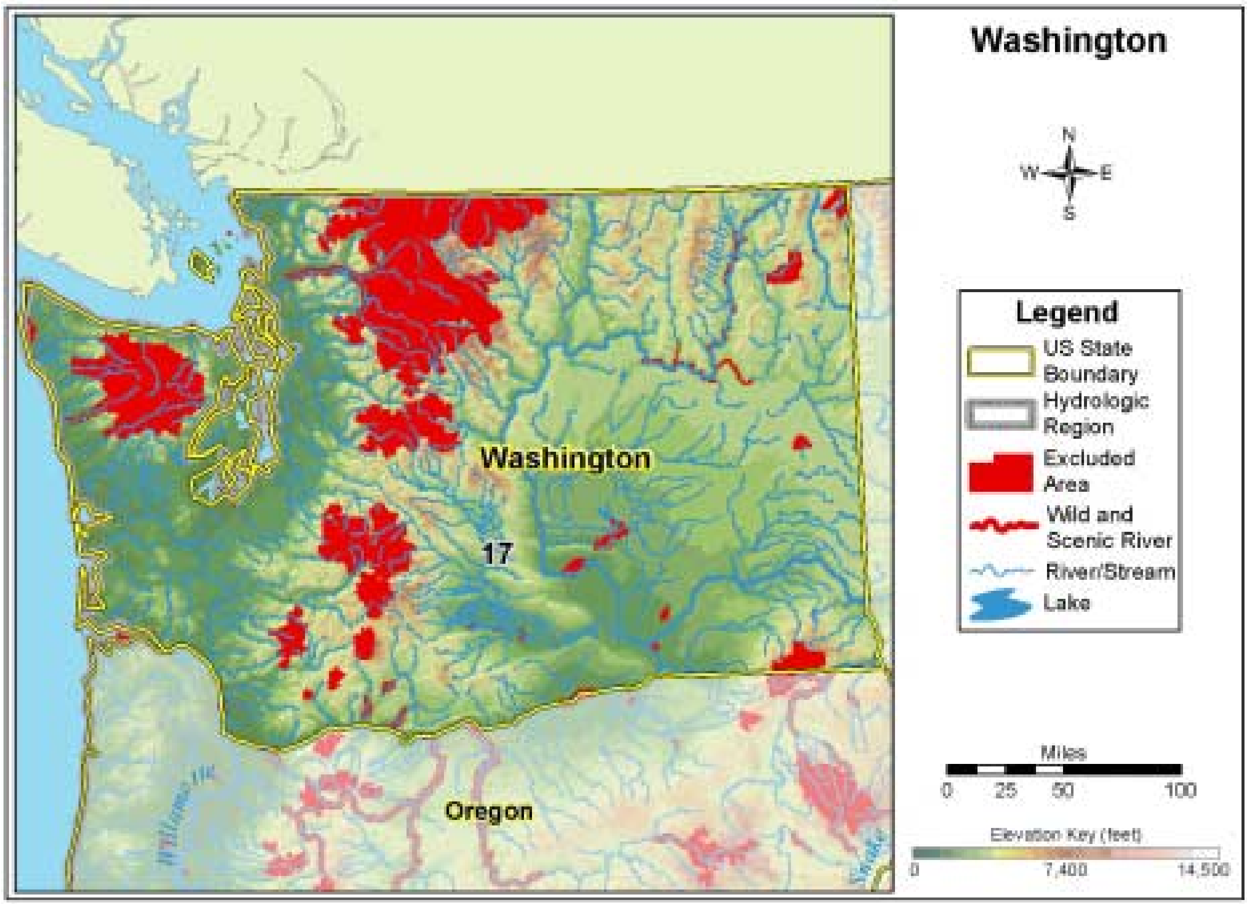


Figure B-221. Washington.

Table B-45. Summary of results of hydropower resource assessment of Washington.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**30,803**	**11,470**	**6,893**	**12,440**
TOTAL HIGH POWER	**28,676**	**11,467**	**6,571**	**10,638**
High Head/High Power	**25,969**	**11,467**	**5,901**	**8,601**
Low Head/High Power	**2,707**	**0**	**670**	**2,037**
TOTAL LOW POWER	**2,127**	**3**	**322**	**1,802**
High Head/Low Power	**1,691**	**3**	**296**	**1,392**
Low Head/Low Power	**436**	**0**	**26**	**410**
Conventional Turbine	149	0	11	138
Unconventional Systems	80	0	6	74
Microhydro	207	0	9	198

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

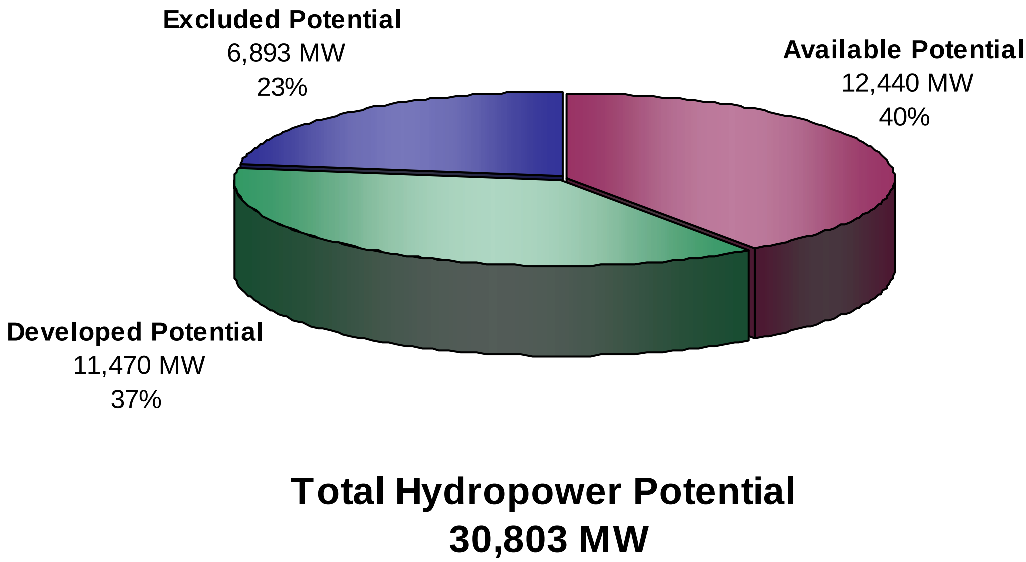


Figure B-222. Distribution of total hydropower potential in Washington.

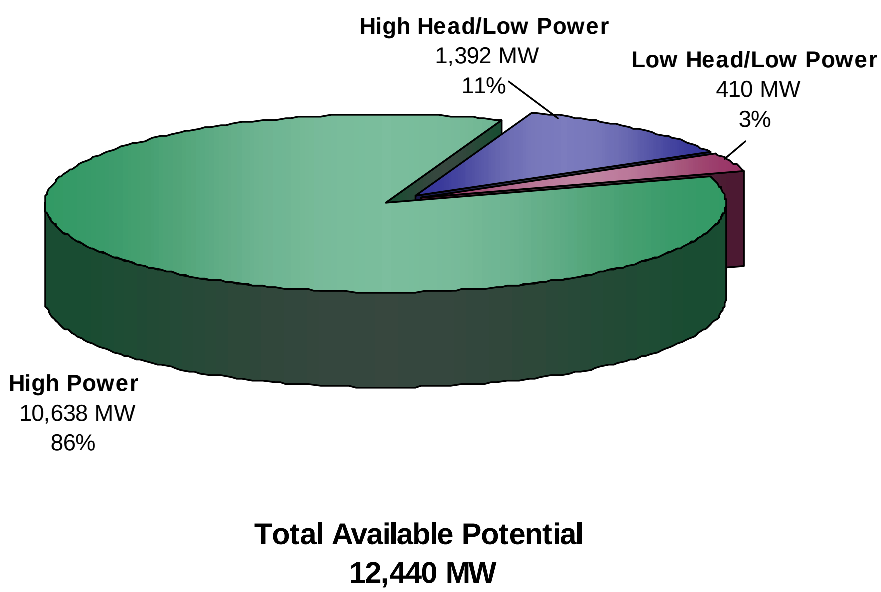


Figure B-223. Distribution of available hydropower potential in Washington.

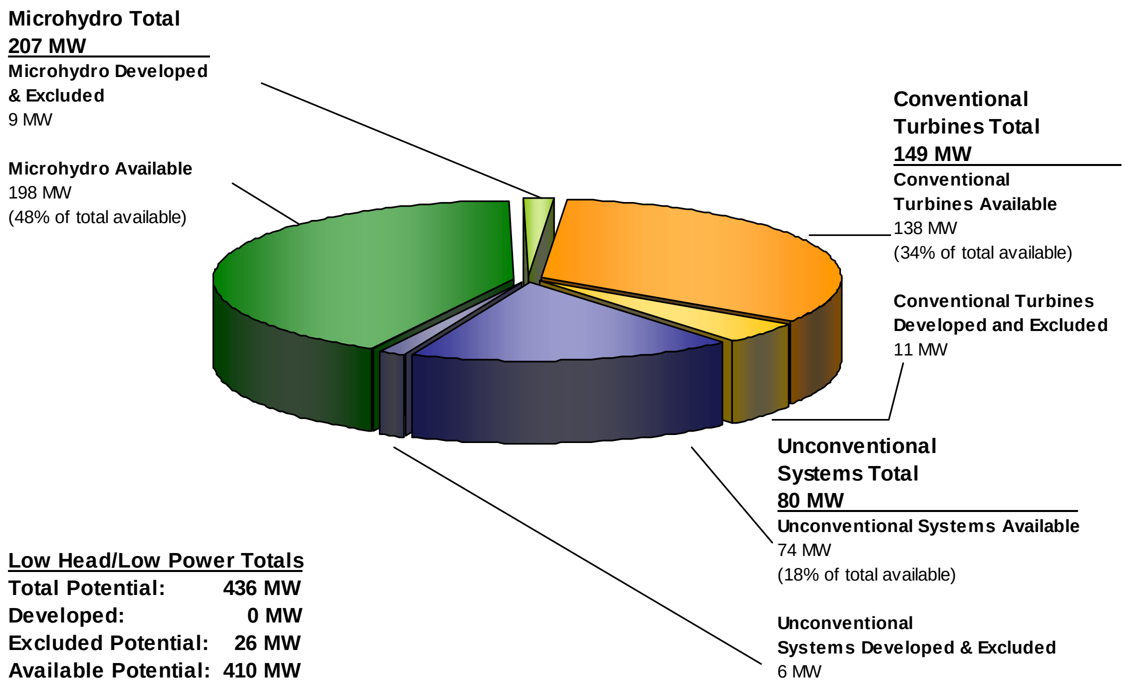


Figure B-224. Distribution of low head/low power hydropower potential in Washington among three low head/low power hydropower technology classes.

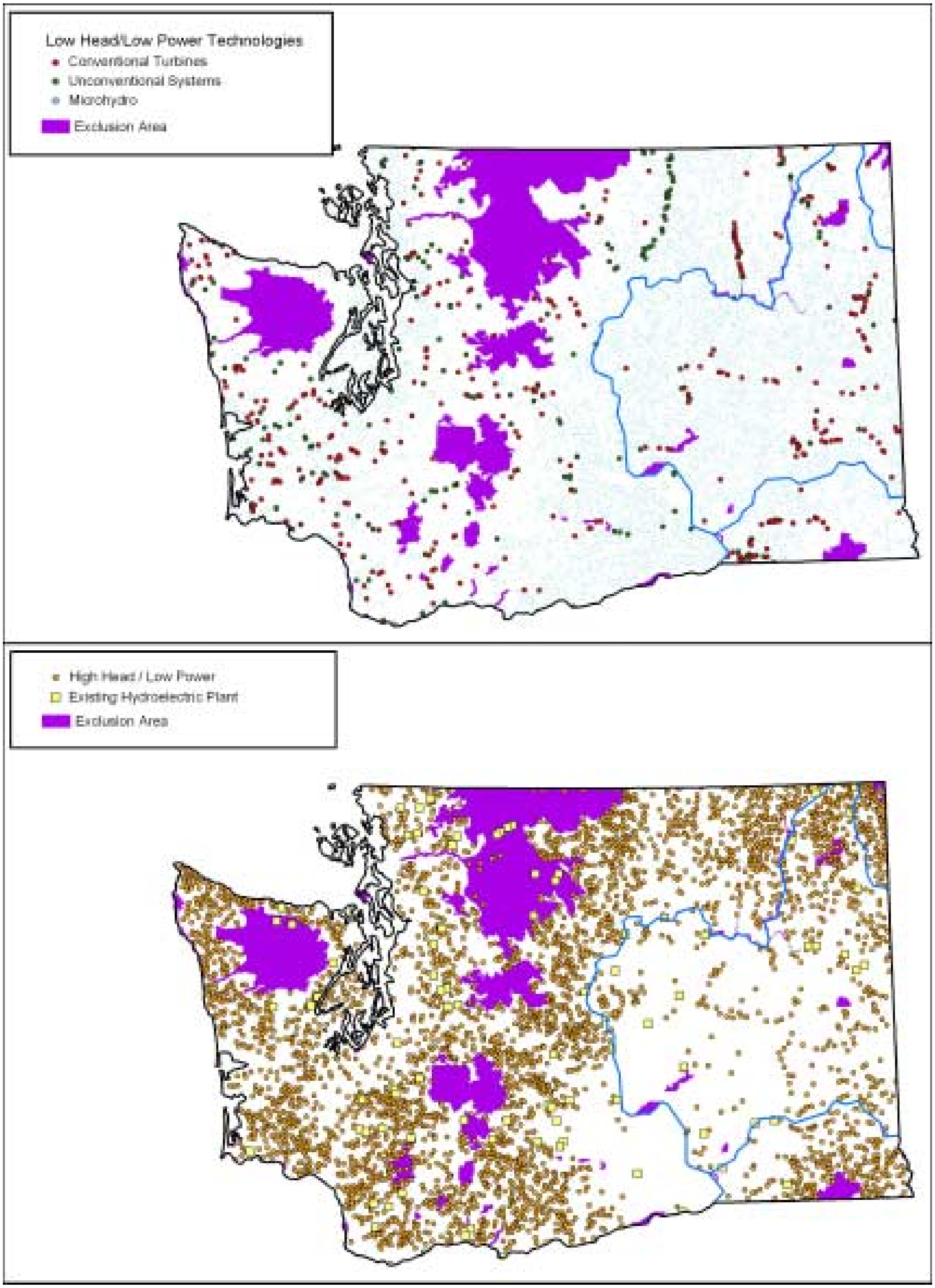


Figure B-225. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Washington.

B.46 West Virginia

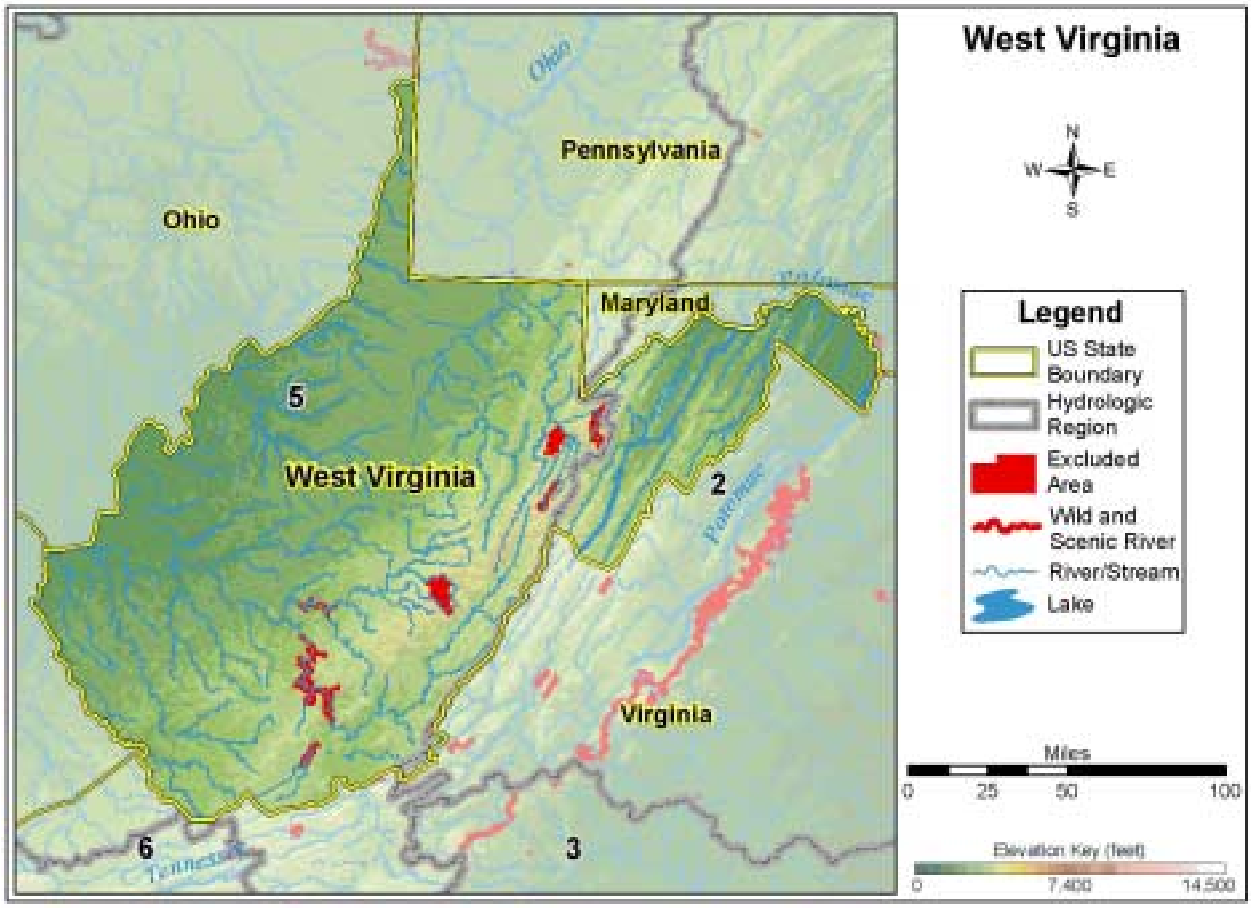


Figure B-226. West Virginia.

Table B-46. Summary of results of hydropower resource assessment of West Virginia.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**3,427**	**140**	**753**	**2,534**
TOTAL HIGH POWER	**2,703**	**140**	**716**	**1,847**
High Head/High Power	**1,832**	**76**	**597**	**1,159**
Low Head/High Power	**871**	**64**	**119**	**688**
TOTAL LOW POWER	**724**	**0**	**37**	**687**
High Head/Low Power	**484**	**0**	**32**	**452**
Low Head/Low Power	**240**	**0**	**5**	**235**
Conventional Turbine	85	0	2	83
Unconventional Systems	33	0	0	33
Microhydro	122	0	3	119

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

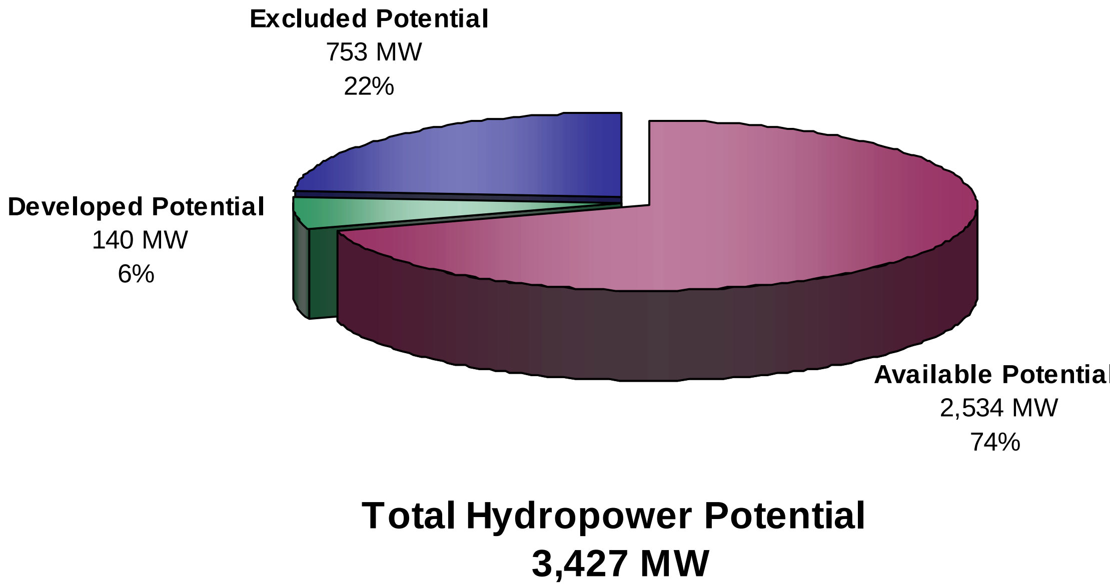


Figure B-227. Distribution of total hydropower potential in West Virginia.

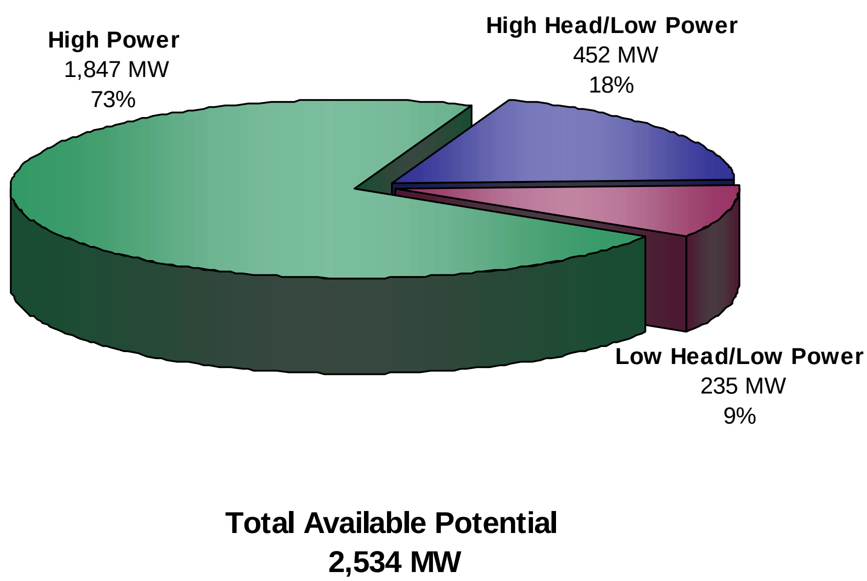


Figure B-228. Distribution of available hydropower potential in West Virginia.

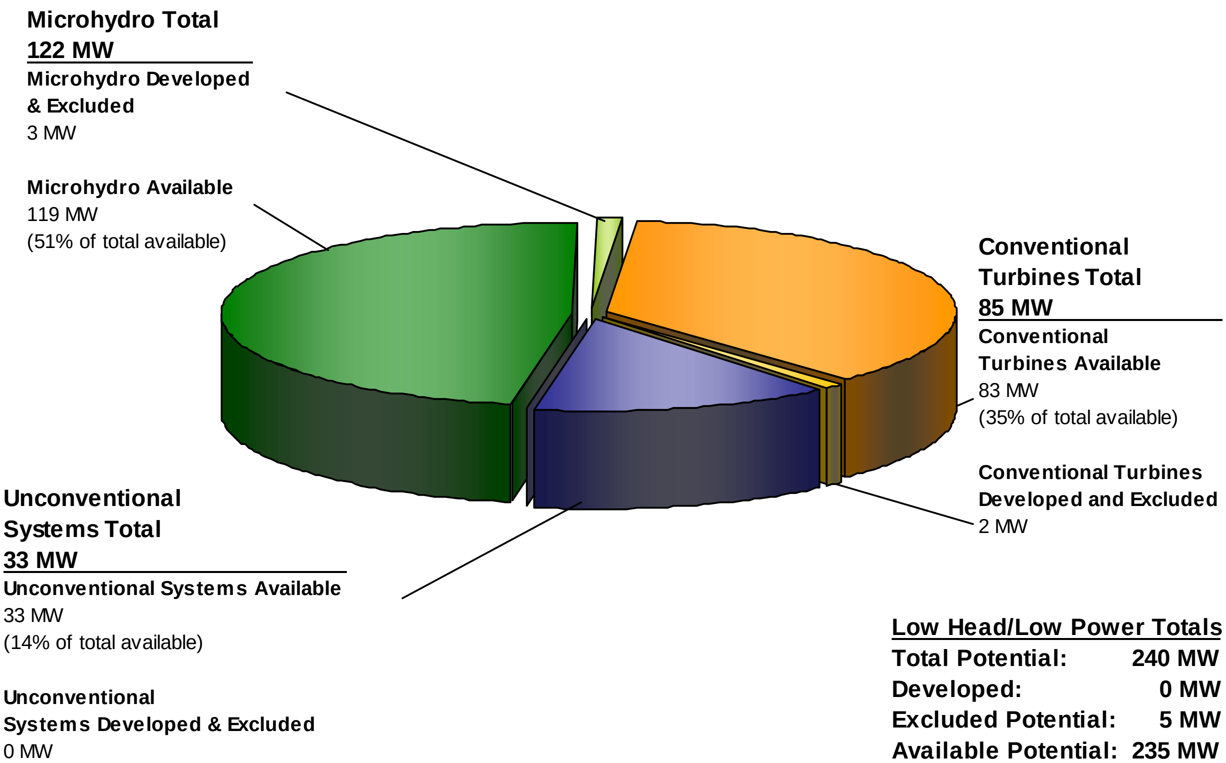


Figure B-229. Distribution of low head/low power hydropower potential in West Virginia among three low head/low power hydropower technology classes.

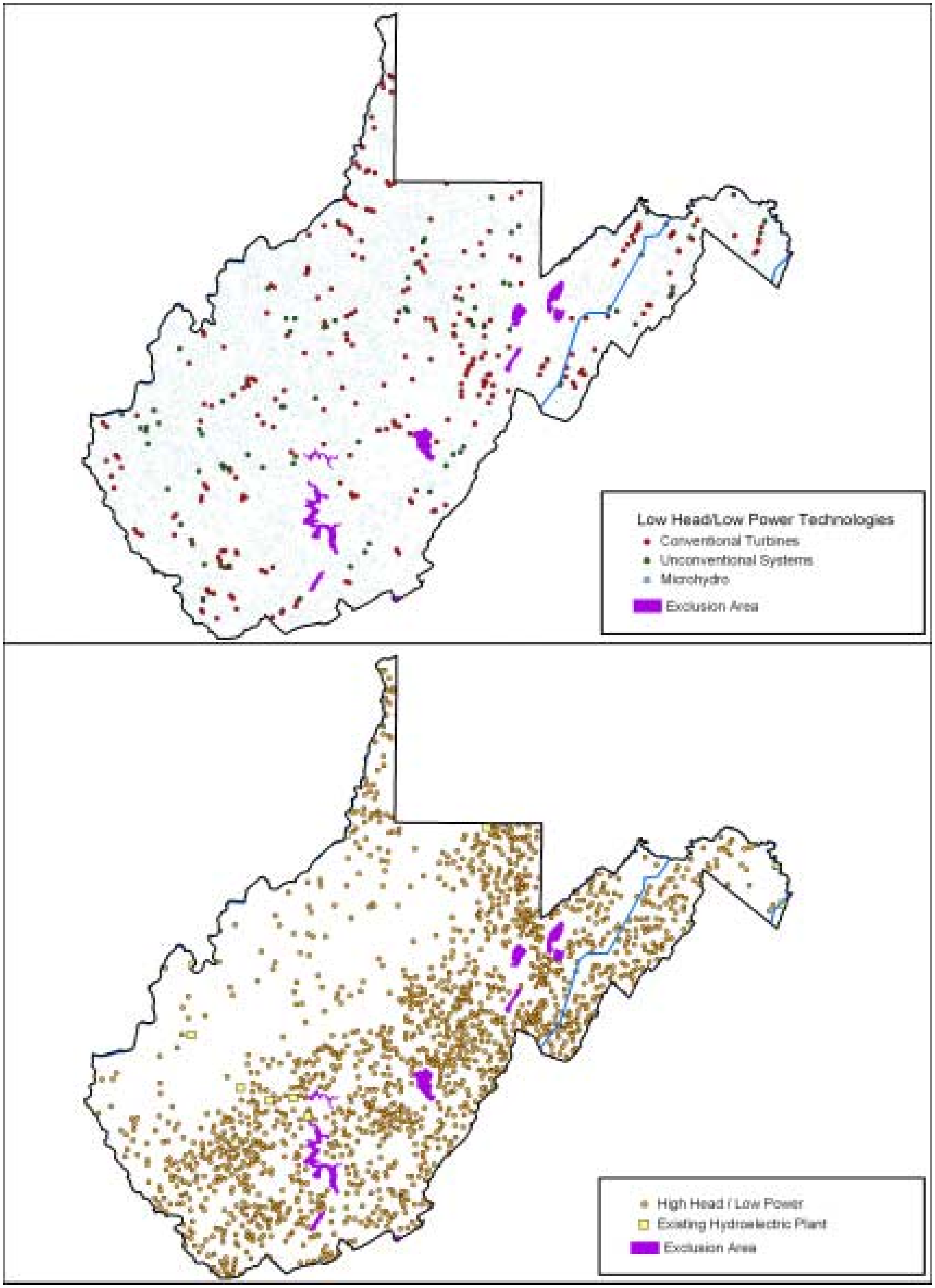


Figure B-230. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in West Virginia.

B.47 Wisconsin

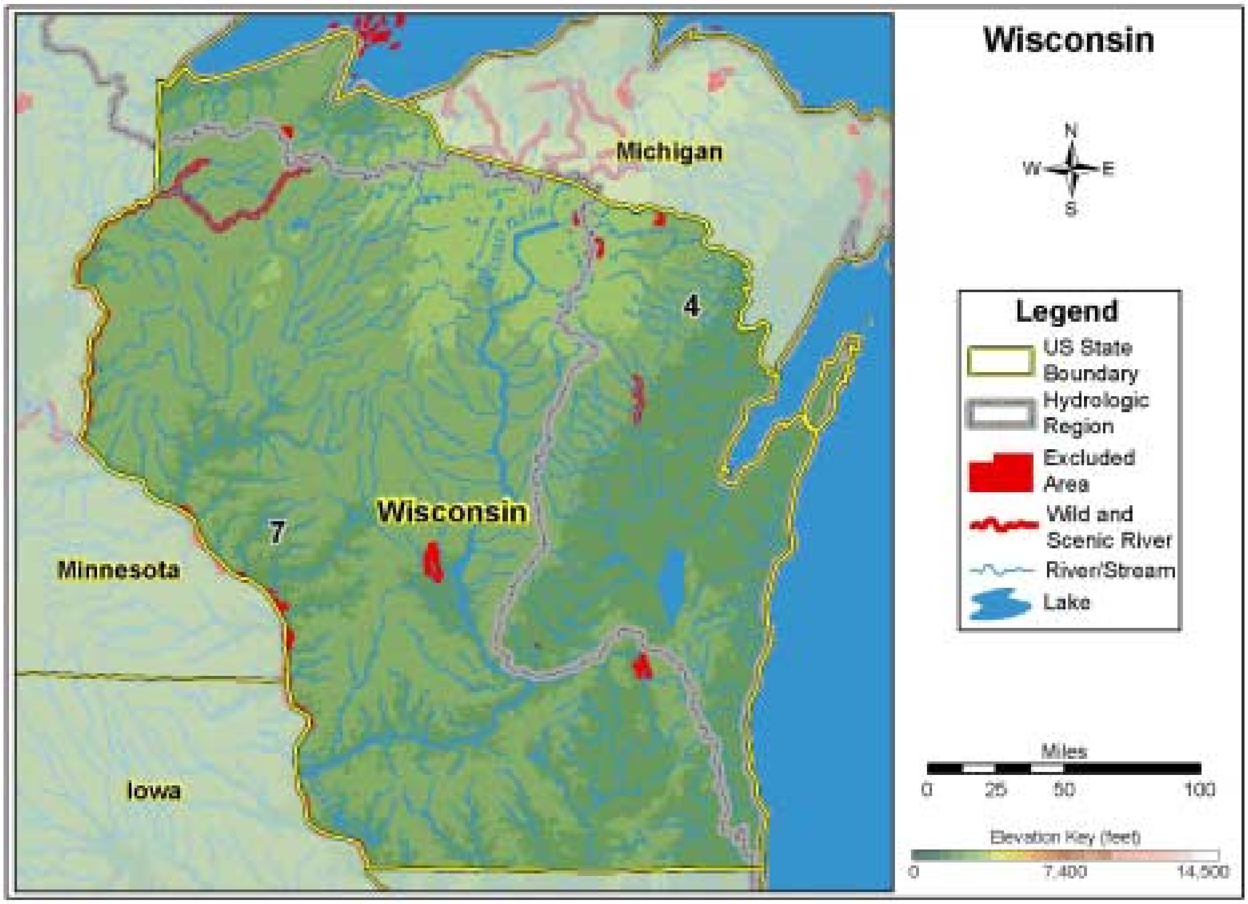


Figure B-231. Wisconsin.

Table B-47. Summary of results of hydropower resource assessment of Wisconsin.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**1,595**	**264**	**189**	**1,142**
TOTAL HIGH POWER	**996**	**254**	**151**	**591**
High Head/High Power	**502**	**172**	**24**	**306**
Low Head/High Power	**494**	**82**	**127**	**285**
TOTAL LOW POWER	**599**	**10**	**38**	**551**
High Head/Low Power	**149**	**1**	**7**	**141**
Low Head/Low Power	**450**	**9**	**31**	**410**
Conventional Turbine	157	9	10	138
Unconventional Systems	84	0	16	68
Microhydro	209	0	5	204

Note: No feasibility or availability assessments have been performed. “Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

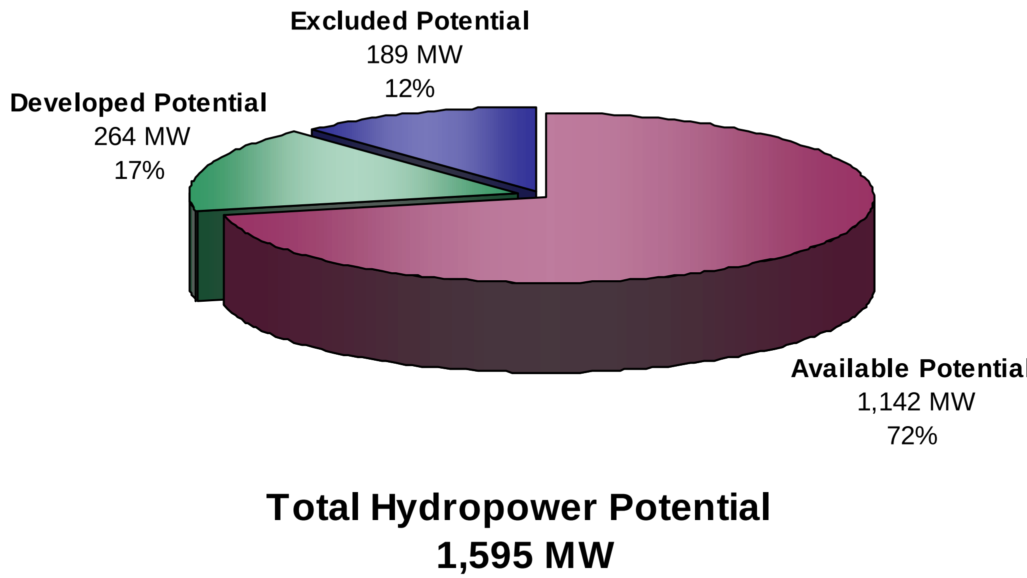


Figure B-232. Distribution of total hydropower potential in Wisconsin.

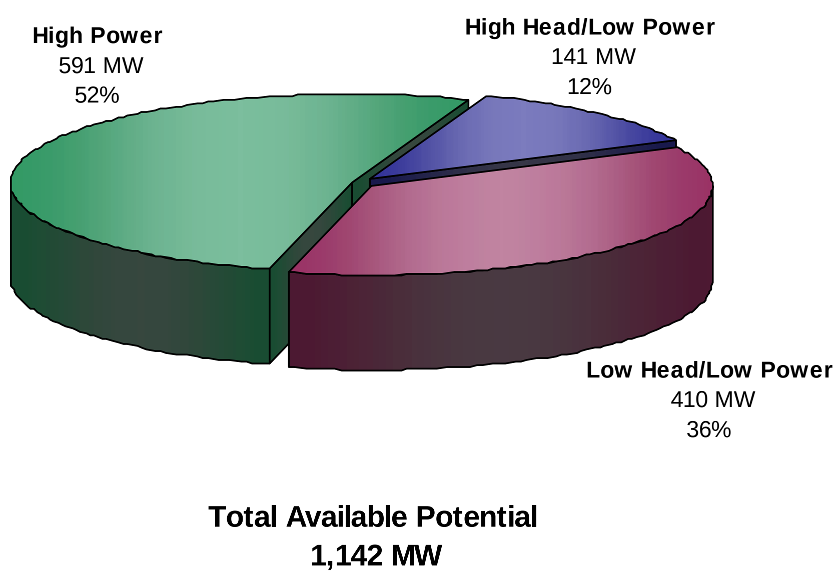


Figure B-233. Distribution of available hydropower potential in Wisconsin.

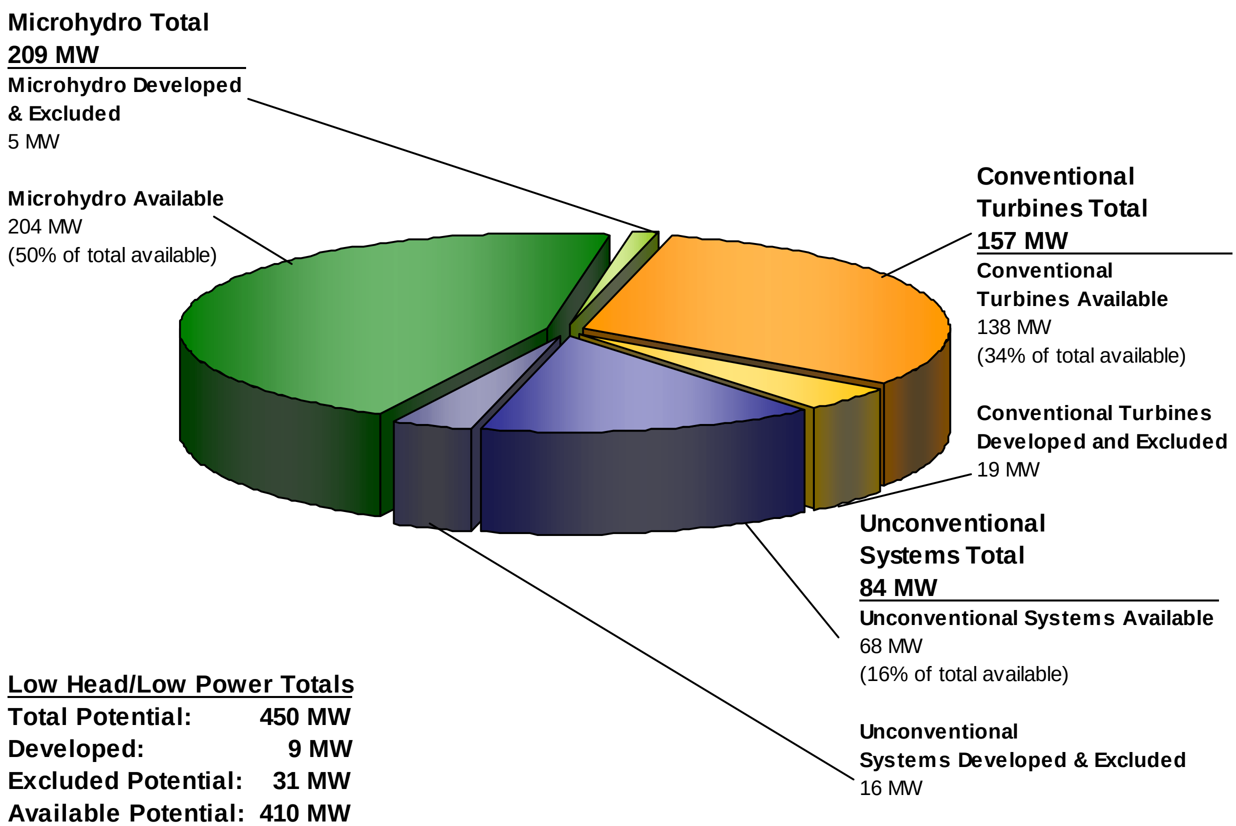


Figure B-234. Distribution of low head/low power hydropower potential in Wisconsin among three low head/low power hydropower technology classes.

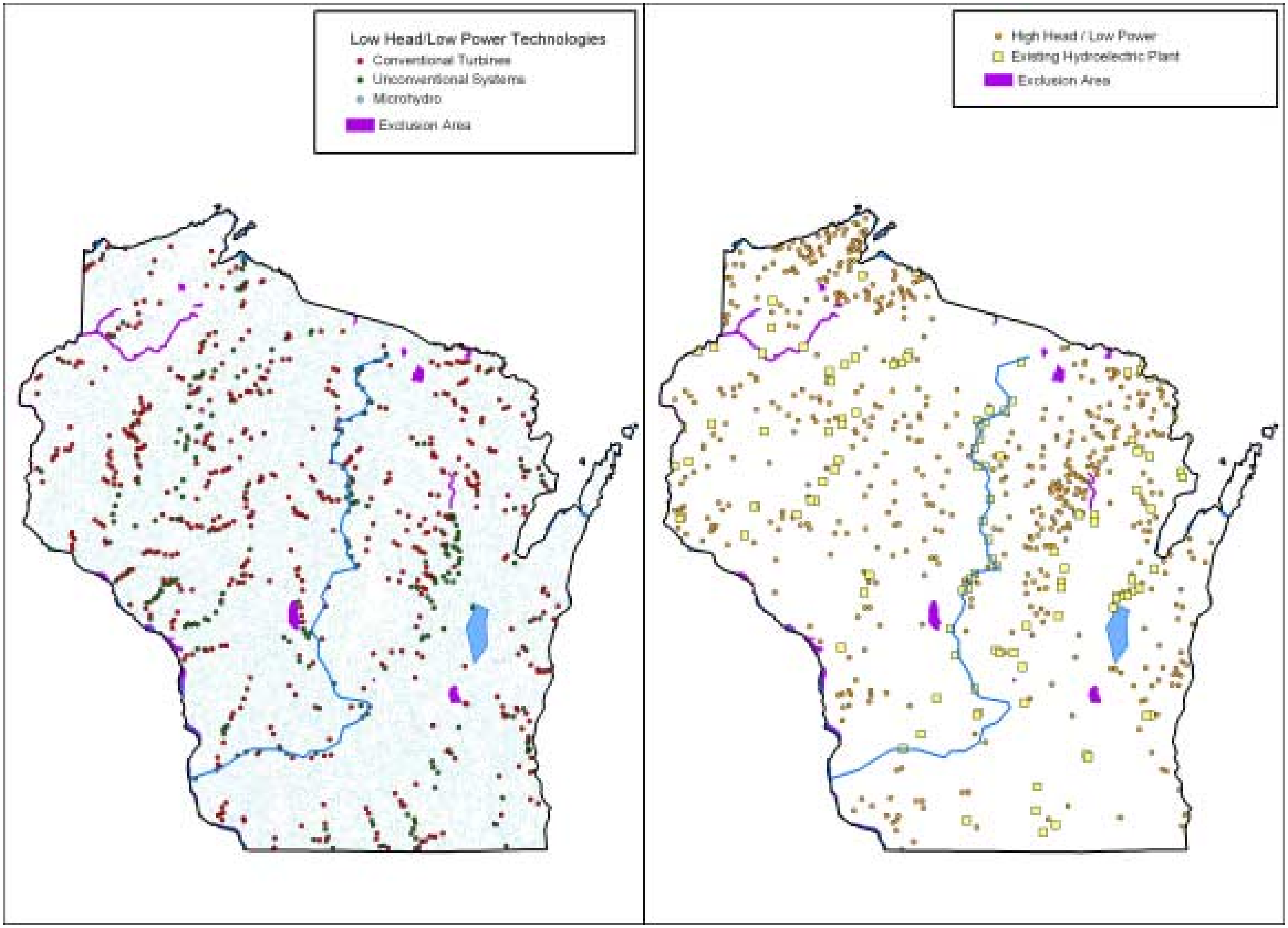


Figure B-235. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Wisconsin.

B.48 Wyoming

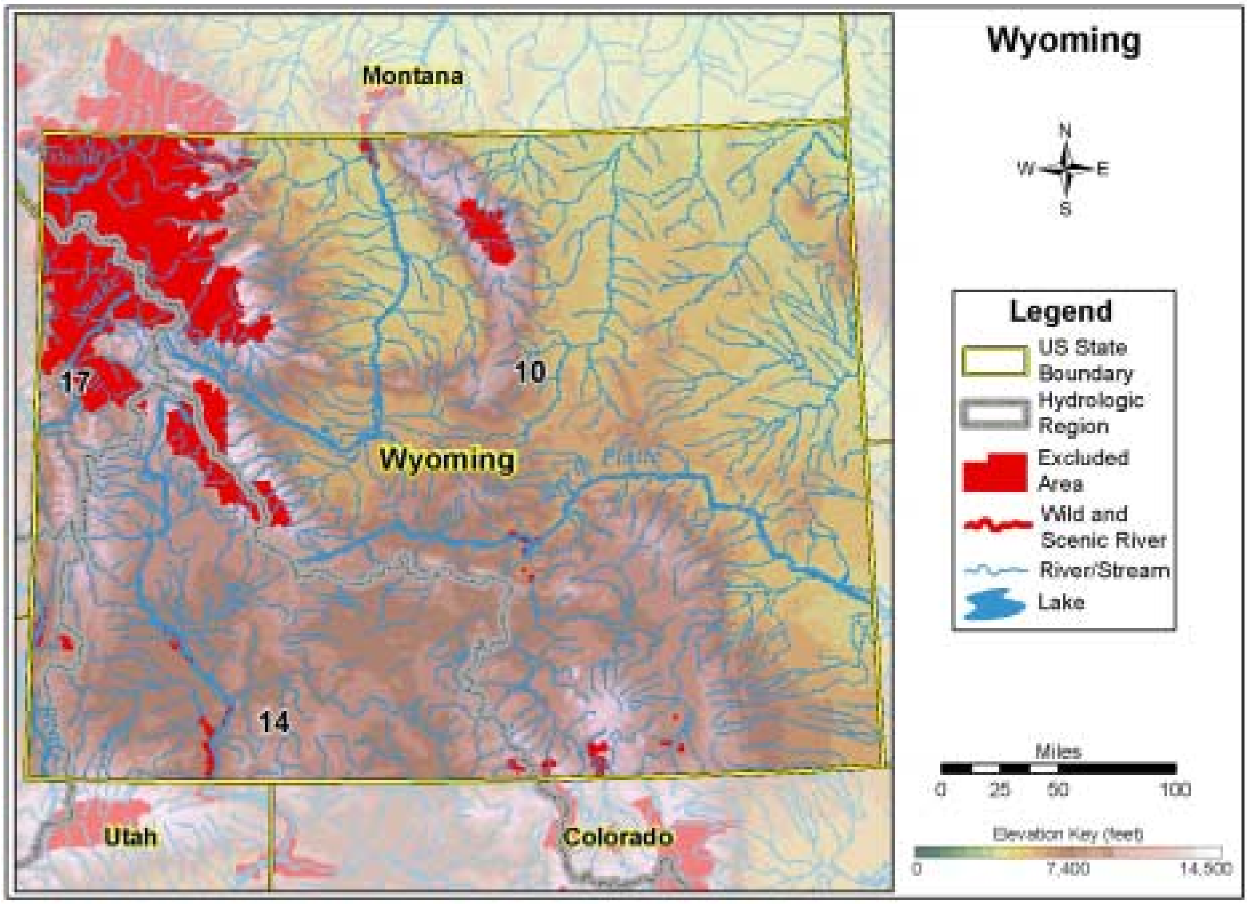


Figure B-236. Wyoming.

Table B-48. Summary of results of hydropower resource assessment of Wyoming.

Power in MW	Total	Developed	Excluded	Available
TOTAL POWER	**6,058**	**117**	**2,768**	**3,173**
TOTAL HIGH POWER	**4,231**	**117**	**2,211**	**1,903**
High Head/High Power	**3,934**	**117**	**2,150**	**1,667**
Low Head/High Power	**297**	**0**	**61**	**236**
TOTAL LOW POWER	**1,827**	**0**	**557**	**1,270**
High Head/Low Power	**1,299**	**0**	**497**	**802**
Low Head/Low Power	**528**	**0**	**60**	**468**
Conventional Turbine	221	0	27	194
Unconventional Systems	59	0	12	47
Microhydro	248	0	21	227

Note: No feasibility or availability assessments have been performed. "Available" only indicates net potential after subtracting developed and excluded potentials from total potential.

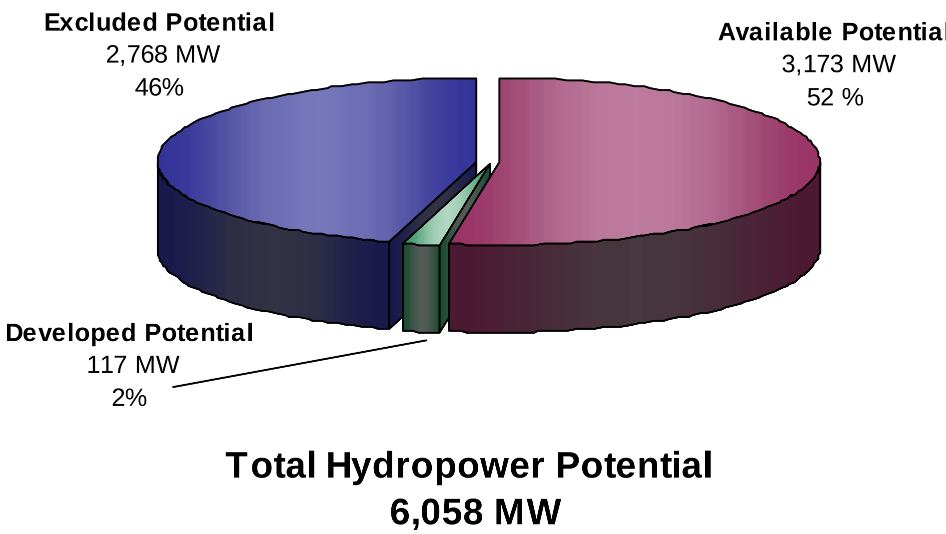


Figure B-237. Distribution of total hydropower potential in Wyoming.

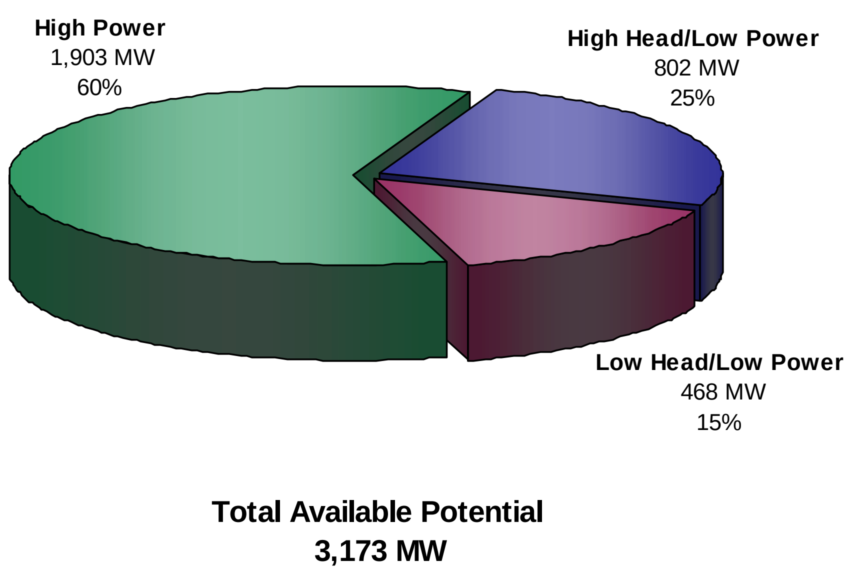


Figure B-238. Distribution of available hydropower potential in Wyoming.

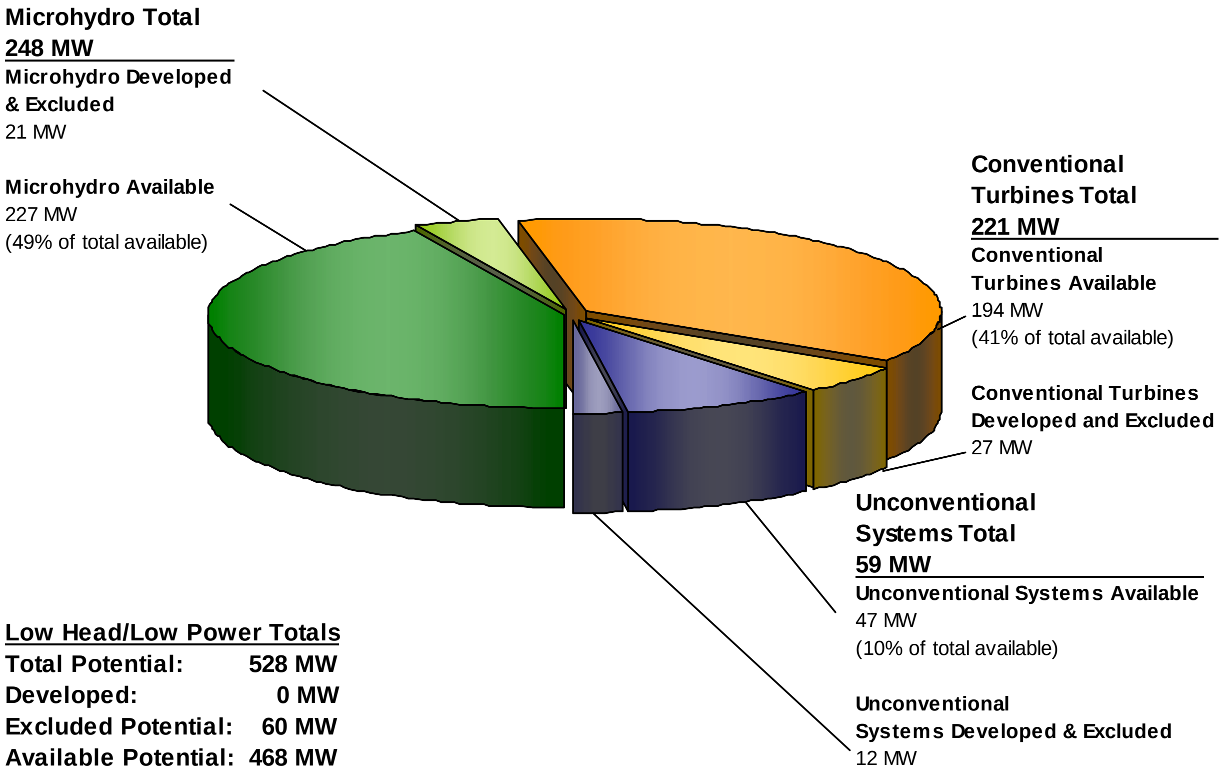


Figure B-239. Distribution of low head/low power hydropower potential in Wyoming among three low head/low power hydropower technology classes.

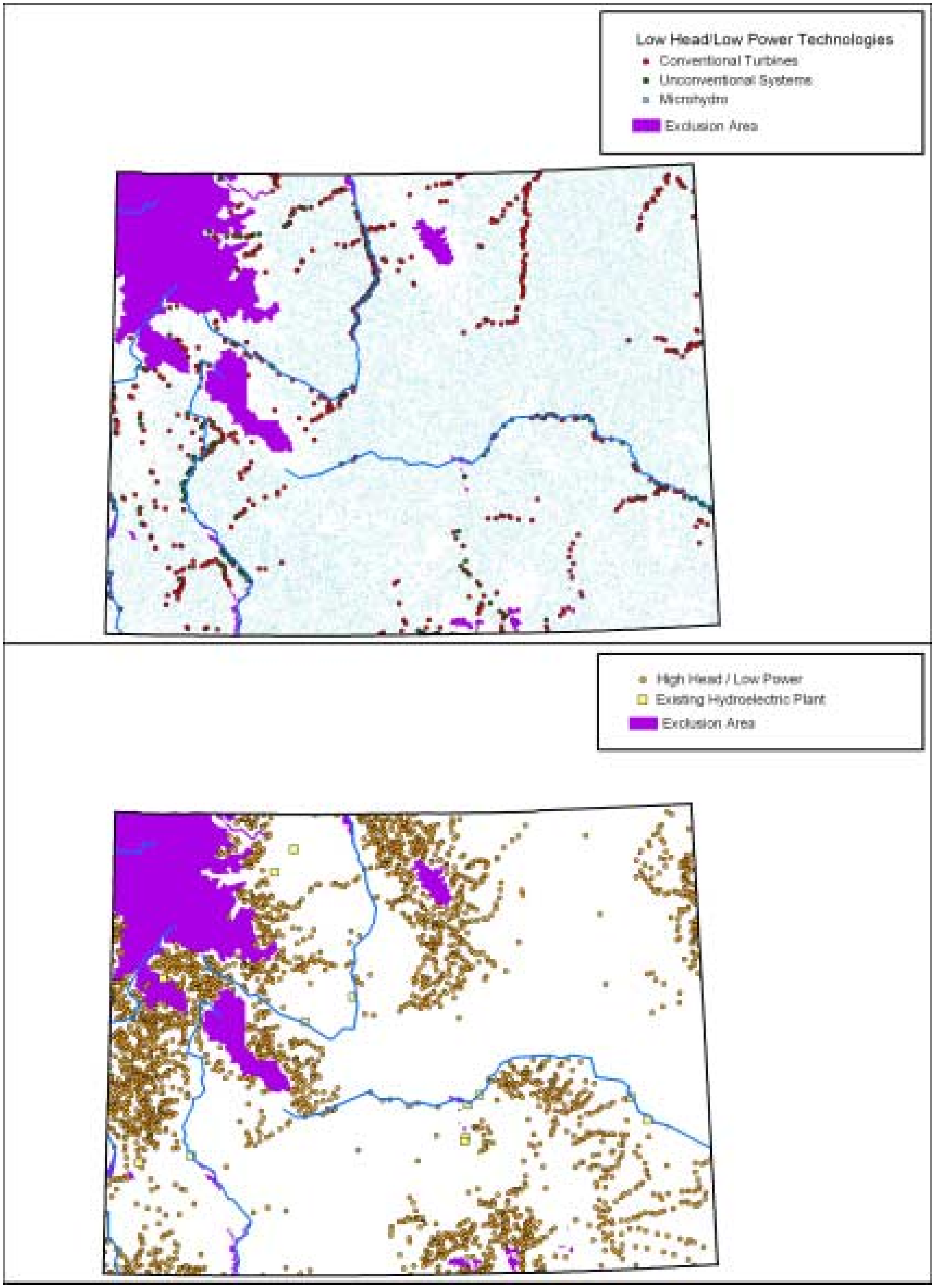


Figure B-240. Low head/low power potential sites, high head/low power sites, and existing hydroelectric plants in Wyoming.